(2)

MTL TR 89-27

AD

COMPARATIVE ANALYSIS OF ULTRA-SONIC INSPECTION PROCEDURES FOR KAMAN K747 ROOT END FITTINGS

WALTER N. ROY, PHILIP G. BENNETT, and
BRADLEY M. TABER III
MATERIALS TESTING AND EVALUATION BRANCH

April 1989

Approved for public release; distribution unlimited.

US ARMY
LABORATORY COMMAND
MATERIALS TECHNOLOGY LABORATORY

U.S. ARMY MATERIALS TECHNOLOGY LABORATORY
Watertown, Massachusetts 02172-0001

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER MTL TR 89-27	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) COMPARATIVE ANALYSIS OF ULTRASONIC INSPECTION PROCEDURES FOR KAMAN K747 ROOT END FITTINGS		5. TYPE OF REPORT & PERIOD COVERED Final Report 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Walter N. Roy, Philip G. Bennett, and Bradley M. Taber III		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Army Materials Technology Laboratory Watertown, Massachusetts 02172-0001 SLCMT-MRM		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS Code: P730000
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army Aviation Systems Command St. Louis, MO 63120		12. REPORT DATE April 1989 13. NUMBER OF PAGES 63
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Aluminum ,	Rotor blades ,
Ultrasonics ,	Stress corrosion ,
Attack helicopters ,	Hydrogen embrittlement ,

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

(SEE REVERSE SIDE)

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

Block No. 20

ABSTRACT

This report provides a comparative analysis of two ultrasonic inspection procedures for Kaman Aerospace Corporation's K747 root end fittings. The procedure currently being used was originally developed by Truton under contract through Kaman Aerospace, the fabricator of the root end fitting. The other procedure is a revision of the existing Truton procedure which was prepared by the U.S. Army Materials Technology Laboratory (MTL). Both procedures were compared against a sample of ten previously rejected root end fittings.

CONTENTS

EXECUTIVE SUMMARY

This report provides a comparative analysis of two ultrasonic inspection procedures for Kaman Aerospace Corporation's K747 root end fittings. The procedure currently being used was originally developed by Truton under contract through Kaman Aerospace, the fabricator of the root end fitting. The other procedure is a revision of the existing Truton procedure which was prepared by the U. S. Army Materials Technology Laboratory (MTL). Both procedures were compared against a sample of ten previously rejected root end fittings. Table 1 provides, at a glance, the major differences between the two procedures.

Table 1. COMPARATIVE SUMMARY BETWEEN ROOT END FITTING INSPECTION PROCEDURES

	Truton	MTL
Wedge Angles	50, 60	45, 55, 65, 67
Transducers	5.0 MHZ (All) 0.250" Diam (All)	5.0 MHz (All) 0.250" Diam (45, 55, 65) 0.1875" Diam (67)
Wedge Contour	4.75" (All)	4.75" (Large O.D.) 3.75" (Small O.D.)
Calibration Standard	Same Principle with Slight Design Changes	
Rejection Criteria		Modified DAC Curve Flat Level

Findings

The Truton procedure is more sensitive than originally planned; i.e., rejects on a 3/64-inch size flaw. This is due primarily to the selection of the 50- and 60-degree angles which are not optimum when used with the existing calibration standard. As a result, a higher gain is needed to bring the signals to 100% screen height than is necessary with the 45- and 55-degree angles of the MTL procedure. The MTL procedure has been artificially adjusted at the 45-degree and 55-degree angles by adding gain over that required to calibrate on the 3/64-inch hole, thus bringing the results approximately equal to those of the Truton procedure. This practice also makes the MTL procedure more sensitive than originally planned.

The 65-degree angle is more sensitive than the 60-degree angle when scanning the near surface portions of the fitting. A reduction of 3 dB is necessary when using the 65-degree angle to approximate the results achieved by the 60-degree inspection.

The 45-degree and 55-degree angles are more sensitive than the existing 50-degree and 60-degree angles.

The Truton procedure will reject more fittings than the MTL proposed procedure. This is due primarily to the differences in rejection criteria. The Truton procedure uses a Distance Amplitude Correction (DAC) type rejection curve which will reject fittings using smaller screen signals than that proposed by MTL which is based on a uniform height. Whether or not the signals resulting in rejection of the fittings are relevant in any area of the sample fittings has not been investigated. To do so would require destructive testing.

Conclusions

The Truton inspection procedure, when being used by experienced operator personnel, will provide a sensitive inspection. From the standpoint of safety of flight, the procedure is conservative in nature in that it is more likely to reject good root end fittings than accept bad fittings. This is based on our finding that it is more sensitive than originally planned. The Truton procedure is likely to produce operator-to-operator differences in inspection results primarily because of the layout of the calibration standard and the calibration procedure required to establish the DAC-type rejection curve.

The Truton procedure can be improved upon, but none of the suggested revisions within the report is considered mandatory in view of the conservative nature of the existing procedure. As a result, the major significance of the report is to serve to substantiate the sensitivity of the existing procedure and provide the PM Cobra with the option of implementing improvements if desired.

INTRODUCTION

This report provides a detailed comparison of procedures for ultrasonically inspecting Kaman Aerospace Corporation's K747 root end fittings for the U.S. Army AH-1 Cobra Helicopters. These inspections are necessary because defects are occurring at the forging parting plane of the fittings. If defect size reaches a critical point, an in-service failure would result, possibly causing loss of life and aircraft.

Discussed first is the need for inspecting the fittings. The Truton/Aerospace inspection procedure, which is now the approved procedure, is then presented. Some difficulties with the calibration and inspection procedure prompted the U.S. Army Materials Technology Laboratory (MTL) to re-evaluate them. A new procedure has been written and is explained. Test result data is illustrated to compare the procedures.

BACKGROUND/HISTORY

The root end fitting is a forged, high-strength aluminum alloy 7049 in the overaged T73 condition (Figure 1). This alloy has a high resistance to stress corrosion cracking.[1] The root end fitting is the part of the rotor assembly which holds the blade to the helicopter (Figure 2).

During the forging process, the excess aluminum is forced out of an opening in the die. The grains at this area, called the parting plane, are unidirectional. There is a strong likelihood of defects occurring in this area. The forces being applied to these fittings while in service could cause the defects to propagate, potentially resulting in failure. Defect propagation has also been found to occur when the fittings are in storage. The cause of these defects is mostly attributed to hydrogen embrittlement, which is possibly a form of stress corrosion.[2] This condition occurs when the fitting is in the hot, humid environment of the blade box.[3] The defects have a planar orientation parallel to the unidirectional grains in the parting plane.

TRUTON/AEROSPACE INSPECTION PROCEDURE

The original procedure was written by Truton Nondestructive Testing Services, a private company contracted by Kaman to develop a test for the fittings. Truton developed a portable ultrasonic procedure utilizing shear waves. Aerospace Testing Lab was also contracted by Kaman to provide a third revision to the procedure, Truton having completed the first two revisions. The inspections are currently being performed every 120 days. This report will consider the procedure singly without regard to the specific author of a given section. See Appendix I for a copy of the current revision. The following paragraphs will summarize the major portions of Truton/Aerospace's procedure.

1. BUSCEMI, C. D. *Failure Analysis of AH-1 Helicopter Blade Root Fitting.* October 29, 1986, p. 1.
2. KULA, E. B. *Trip Report to AVSCOM, St. Louis, MO, 8 January 1987.* January 28, 1987, p. 1.
3. Kaman Aerospace Corporation, *K747 Root Fitting Investigation Status Report.* January 8, 1987.

Personnel

Personnel are to be certified in Ultrasonics to Level II or III in accordance with MIL-STD-410.

Transducers/Wedges

The required transducers have a frequency of 5 MHz and a size of 0.25 inch. They are fitted with wedges to transmit 50-degree and 60-degree shear waves into the fitting. The face of each wedge is concaved to match the fitting's large outside diameter of 4.75 inches (Figure 3).

Calibration Standard

The calibration standard is made using the same material, configuration, and fabrication process as that of the root end fitting (Figure 4). There are four 3/64-inch diameter flat bottom holes (FBHs) drilled into portions of the two diameters to be tested. These holes are used for creating the DAC curves used in the inspections. EDM notches used to calibrate the horizontal sweep range are also cut into the standard.

Calibration Procedure

The first calibration which the procedure calls for is the horizontal sweep range. This is accomplished by first establishing the beam exit point of the 60-degree probe using an EDM notch on the standard. The exit point reflection is set at the 0 division on the horizontal scale. Then, the same notch is located from a circumferential surface distance of 2.125 inches. This reflection is set at 7 divisions on the horizontal scale. When setting the second reflection, the first may have shifted slightly. If so, then the first step must be repeated. This whole process must be repeated until the reflections can be seen at 0 and 7 divisions.

The DAC curve establishes the sensitivity of the examination. The procedure calls for each probe to reflect sound from two FBHs in the thick section of the standard to produce three points on the screen (one FBH being struck twice at different distances). From these points, separate DAC curves are created for each probe. On a designated initial FBH for each probe, the reflection is maximized and the gain adjusted to display the reflection at 100% screen height. The other two FBH reflections for each probe yield smaller amplitudes. Only the 60-degree probe is moved onto the thin section of the standard. The reflection from its FBH is maximized, and the gain is adjusted to match the already established 60-degree DAC curve.

Inspection Data

There is a standard ultrasonic response log sheet onto which all data is to be recorded. The data is recorded as a percentage value of the inspection signal amplitude compared to that of the corresponding point on the DAC curve. All indications which are equal to or greater than 30% are recorded. All indications which are greater than 100% are cause for rejection.

DIFFICULTIES WITH THE TRUTON/AEROSPACE INSPECTION PROCEDURE

There are several difficulties associated with the Truton/Aerospace calibration and inspection procedure. These difficulties are discussed in the following paragraphs.

Transducer Wedge Diameter

The transducer wedge diameter is required to be machined to 4.75 inches (Figure 3), which matches the larger outside diameter of the fitting. The same 60-degree probe is used to calibrate and inspect the smaller diameter of 3.75 inches. When this is done, there is considerable front-to-back wobble which alters the angle at which the soundwave is striking the FBH or the defects. These angle changes have a considerable influence on the magnitude of the reflections.

Transducer Wedge Angles

The transducer wedge angles have not been selected for maximum sensitivity during calibration. When performing the calibration procedure, the 60-degree shear wave is required to hit FBH #2 from 1.25 inches away from the parting plane, FBH #1 from 0.25 inch away, FBH #1 from 2.125 inches away, and FBH #4. There is no guidance as to the distance for FBH #4.

The 60-degree shear wave that hits FBH #2 from 1.25 inches simultaneously hits FBH #1. Although the reflection from FBH #2 is not perpendicular, the superimposition of the FBH #1 reflection increases the overall indication amplitude. This becomes obvious upon review of Figure 5, which shows the center of the beam approximately midway between FBH #2 and FBH #1. The soundwave that hits FBH #1 from 0.25 inch does not hit the bottom perpendicularly, causing a decrease in reflection magnitude. If it did hit perpendicularly, the magnitude of a reflected soundwave would be greater than that of FBH #2, because of the reduced sound path distance (SPD) (Figure 6). The soundwave that hits FBH #1 from 2.125 inches (Figure 7) is also not perpendicular to the bottom. This soundwave will have to skip off of the outside diameter before returning to the transducer. In addition, the beamspread of the soundwave also hits FBH #2, causing an additional reflection.

The procedure calls for a reflection from FBH #4 using the 60-degree probe on the thin section of the standard, but gives no guidance as to the circumferential distance from the bottom of the FBH. The best reflection is achieved at a distance of approximately 1.75 inches (Figure 8). At this point, however, the soundwave still does not hit the bottom of the FBH perpendicularly. The magnitude of the indication suggests that the soundwave is striking the FBH at an angle which permits the reflected sound to return to the transducer after echoing off the surface of the standard. The signal returning to the transducer in this case is also influenced by the reflection from the corner of the FHB where the sound strikes and returns directly to the transducer.

The calibration procedure also requires the use of a 50-degree shear wave. The 50-degree shear wave is required to hit FBH #2 from 1.00 inch away from the parting plane, FBH #3 from 1.25 inches away, and FBH #2 from 1.625 inches away.

The 50-degree shear wave that hits FBH #2 from 1.00 inch does not hit the hole bottom perpendicularly (Figure 9), causing a decrease in reflection magnitude. When hitting FBH #3 from 1.25 inches, the soundwave again does not hit perpendicularly to the bottom (Figure 10). In addition, the beamspread also causes it to hit FBH #2, influencing the size of the on-screen indication. When hitting FBH #2 from 1.625 inches, the soundwave does not directly hit the bottom, and it is also hitting FBH #3 (Figure 11). The 50-degree probe provides little, if any, coverage of the larger section inside diameter, reducing the chances of detecting very small discontinuities.

With so many factors introducing variations, it is difficult to produce a consistent DAC curve for either the 50- or 60-degree probe using these techniques.

Calibration Standard

The calibration standard (Figure 4) is made with the four 3/64-inch FBHs used for calibration. Three of them are vertically lined up. This causes the soundwave beamspread to frequently hit more than one hole at a time, thus influencing the magnitude of the reflected wave.

Calibration Procedure

DAC Curve

Another difficulty with the Truton/Aerospace procedure is in establishing the DAC curve. It is important to have a clear understanding of the DAC curve before it is discussed relevant to the procedure. The DAC curve is set up on the CRT by plotting and connecting points which represent the reflections of several artificial flaws at different depths. The reflecting surfaces of the flaws must be equal in area.

The most common reflector used is the FBH. If a part has several FBHs, all being the same diameter, parallel to each other, but at different depths (Figure 12), their maximum reflections may be used to form a DAC curve. The most important requirements are that the soundwave must strike the same size area of each FBH at the same angle. If a soundwave strikes a FBH at 90 degrees, it will result in a maximum signal amplitude. If the transducer is moved to a position over a second FBH which has been drilled at a 30-degree angle to the first (Figure 13), the maximum signal amplitude will be reduced, even though the material distance and FBH diameter are the same as the first. This problem would be compounded by adding or subtracting material distance from FBH b in Figure 13. If, however, two FBHs with equal diameters located at different material distances from the transducer are struck at 30 degrees (Figure 14), the consistency of the angles between the two FBHs will permit a valid DAC curve to be drawn from the reflections.

The procedure created by Truton/Aerospace is dependent upon a classic setup of a nonelectronic DAC curve. This would be routine if all the FBHs could be struck at the same angle for each DAC curve; however, they cannot. This is because of the curved contour of the standard. When calibrating on a curved surface and setting up a DAC curve on parallel FBHs, a single hole cannot be hit twice at the same angle from different distances without skipping off a surface. Surface skipping creates another problem, which will be discussed in the following section.

Surface Skipping

The Truton/Aerospace procedure utilizes an outside diameter skip when calibrating and inspecting with the 60-degree probe from a distance of 2.125 inches. Figure 7 shows the sound hitting the bottom of the FBH at such an angle that the sound must reflect off of the top surface before it returns to the probe. This will only work consistently if all the couplant is removed from the surface of the fitting from where the wave is going to skip. As much as 20% of the sound can be absorbed and scattered in the couplant, depending on the acoustic impedance of the couplant and the quantity on the surface.

Conclusions

The existing procedure is in actuality more sensitive than originally planned; i.e., capable of detecting a flaw of 3/64-inch size. This is because, in calibrating with the 50- and 60-degree angle wedges, the FBHs are not being struck at an optimum angle, therefore resulting in a smaller reflection. This point was verified when 45- and 55-degree angle wedges were substituted for the 50- and 60-degree wedges and produced larger signals on screen at the same gain setting.

The Truton procedure is prone to variations from operator-to-operator, particularly because the establishment of the DAC curve is very sensitive to transducer positioning. Thus, it is important to use experienced personnel.

Several modifications are possible to improve the precision, accuracy, and ease of use of the existing procedure. A wedge machined to a radius of 3.75 inches would eliminate wobble problems on the smaller diameter. The wedge angles can be modified to strike the calibration FBHs individually and perpendicularly. A new calibration standard has been made with the FBHs spaced so that the beamspread of the soundwave will not strike more than one FBH at a time. Finally, because of the consistency problems when setting up the DAC curve, an alternative method can be developed.

U.S. ARMY MATERIALS TECHNOLOGY LABORATORY INSPECTION PROCEDURE

The procedure created by MTL will: (1) utilize two transducer wedge radii instead of one, (2) utilize four different transducer wedge angles instead of two, (3) utilize a different configuration for the calibration standard, and (4) use a different calibration procedure which replaces the DAC curve with vertical amplitude rejection levels. These changes will simplify the calibration and inspection procedure resulting in increased reliability of the test. See Appendix II for a complete copy of MTL's inspection procedure.

Transducers/Wedges

The transducer wedge angles chosen are 45, 55, 65, and 67 degrees. The 45-, 55-, and 65-degree probes are used for inspecting the larger outside diameter of 4.75 inches. The 67-degree probe is used for inspecting the smaller outside diameter of 3.75 inches. This combination of angles completely covers all areas of concern within the parting plane and reduces the required surface scanning distances, ensuring that the sound from each probe will either strike a flaw perpendicularly or nearly perpendicularly, thereby maximizing amplitudes. This benefit, in combination with more uniform sound travel paths, eliminates the requirement for use of a DAC curve, which will simplify calibration. Figures 15 through 18 illustrate the areas which the transducers cover.

Calibration Standard

The calibration standard's major operational change is an offset FBH #2 (Figure 19). This prevents undesired reflections caused from the soundwave's beamspread striking two FBHs that are too close to one another. Other minor convenience differences include a change in EDM notch position, which will enable verification of both top and bottom surface inspection capability, elimination of countersinks, and graduations spaced every 1/4 inch which indicate the circumferential distances from the bottom of the FBHs.

Calibration Procedure

MTL's calibration procedure is significantly different from that of Truton/Aerospace's. It previously was shown that a consistent DAC curve cannot be produced for this type of inspection. Therefore, MTL has created an alternate method. Each probe will be used to evaluate only the section of the calibration standard that it was designed to cover. The reflection from the FBH in this area will be maximized and the gain set to approximately 80% screen height. This point is then marked on the screen and extended approximately 1.5 divisions on each side. This is done for each of the probes. These lines will represent the rejection levels for the inspection. This will ensure that each section of the parting plane is covered perpendicularly and with a valid rejection threshold.

Test Results

A series of tests was conducted to verify the usability of the new angles. Ten previously rejected fittings were used in the tests. All the test data is contained in Appendix III. The results are summarized in the following paragraphs.

Angle Comparison

The revised angles of 45, 55, 65, and 67 degrees were compared to the original angles of 50 and 60 degrees. This was done by setting the ultrasonic unit at a gain of 70 dB and logging the reflections of the different probes.

The 45-degree probe, which is designed to scan the bottom thick section of the fitting, was compared against the 50-degree probe, which is designed to scan the bottom to middle thick section of the fitting. The 45-degree probe gave 90 indications above 30% screen height while the 50-degree probe gave only 42. There are 33 indications which are located at approximately the same horizontal position for both angles. Comparison of these 33 indications shows that those found with the 45-degree probe averaged 16% higher than those found with the 50-degree probe.

The 55-degree probe, which is designed to scan the middle thick section of the fitting, was compared to both the 50- and 60-degree probes, which overlap while scanning the middle thick section of the fitting. When comparing the 55-degree probe to the 50-degree probe, the 55-degree probe gave 44 indications above 30% screen height while the 50-degree probe gave 42. There are 27 indications which are located at approximately the same horizontal position for both angles. The 55-degree probe's indications averaged approximately the same as the indications of the 50-degree probe. When comparing the 55-degree probe with the 60-degree probe, the 55-degree probe gave 44 indications above 30% screen height while the 60-degree probe gave only 1. There were no indications which were located at approximately the same horizontal position for both angles.

The 65-degree probe, which is designed to scan the top thick section of the fitting, was compared to the 60-degree probe, which is designed to scan the top to middle thick section of the fitting. The 65-degree probe gave 1 indication above 30% screen height while the 60-degree probe also gave 1. Both indications are located at approximately the same horizontal position. The 65-degree probe's indication was 53% higher than the indication of the 60-degree probe.

It was decided to reinspect the 10 fittings using the 65- and 60-degree probes because only 1 indication was found on each. However, the gain was increased to 80 dB. The 65-degree probe gave 39 indications above 30% screen height while the 60-degree probe gave 30. There are 16 indications which are located at approximately the same horizontal position for both angles. The 65-degree probe's indications averaged 17% higher than the indications of the 60-degree probe.

The 67-degree probe, which is designed to scan the thin section of the fitting, was compared to the 60-degree probe, which is also designed to scan the thin section of the fitting. Neither the 67- nor 60-degree probes gave any reportable indications during this test.

This series of tests confirms that the revised angles of 45, 55, and 65 degrees provide for a more sensitive inspection that will detect more defects and give indications of higher amplitude.

Procedure Comparison Without Amplitude Correction Factor

Another series of tests was conducted to compare MTL's procedure with that of Truton/Aerospace. The test results are included in Appendix IV. The results are summarized in the following paragraphs.

MTL's 45-degree probe gave no reportable indications. This is due to the near-perfect perpendicularity of the sound striking the FBH in the standard, resulting in a substantially reduced gain setting during the actual testing. When the sample fittings were tested, it was necessary to increase the gain by 20 dB in order to achieve results comparable to those achieved using the 50-degree transducer.

MTL's 55-degree probe was compared to Truton/Aerospace's 50- and 60-degree probes. The 55-degree probe detected 25 reportable indications while the 50-degree probe detected 67 and the 60-degree probe detected 33. There are 24 indications which are located approximately at the same horizontal position on the 50- and 55-degree probes and 18 indications on the 60- and 55-degree probes. The 55-degree probe's indications averaged 39% lower than the indications of the 50-degree probe and 1% higher than the indications of the 60-degree probe. The reason the indications are lower when using the 55-degree probe is again due to the reduced gain setting necessitated by the sound striking the FBH more perpendicularly when calibrating. To achieve the same rejection level that is established with the current procedure, the gain would have to be increased by 8 dB when using the 55-degree probe.

MTL's 65-degree probe was compared to Truton/Aerospace's 60-degree probe. The 65-degree probe detected 37 reportable indications while the 60-degree probe detected 33. There are 18 indications which are located at approximately the same horizontal position for the 65- and 60-degree probes. The 65-degree probe's indications averaged 86% higher than the indications of the 60-degree probe. The reason the indications are higher when using the 65-degree probe is due to the significantly better angle at which the 65-degree soundbeam strikes the defects. To achieve the same rejection level that is established with the current procedure, the gain would have to be decreased by three dB when using the 65-degree probe.

Neither Truton/Aerospace's 60-degree probe nor MTL's 67-degree probe gave any reportable indications. From this, it can be deduced that there are no defects occurring at the center portion of the fittings that were tested.

MTL's Procedure Comparison with Amplitude Correction Factors

Upon incorporating the amplitude correction factors into the MTL procedure, the inspection results approximated those from Truton/Aerospace. The results are included in Appendix V. It is impossible to directly correlate the data because of the many variations between the procedures. The desired result was a rejection rate comparability. This was achieved.

Table 2 compares the performance of each procedure against the sample root end fittings. As can be seen from the table, the Truton procedure rejected seven fittings while the MTL procedure rejected six fittings. It should be noted that none of the fittings has been destructively tested to identify the specific metallurgical cause of the indications.

Table 2. COMPARISON OF PROCEDURE PERFORMANCE
(Angle Rejection Summary)

Sample Fitting S/N	Truton			MTL			
	50	60 (Thick)	60 (Thin)	45	55	65	67
B5328	R*	A	A	A	R	A	A
B5102	A†	A	A	A	A	A	A
B5298	R	A	A	R	R	A	A
B4994	R	A	A	A	A	A	A
B5227	R	A	A	A	R	A	A
B4906	A	A	A	A	A	R	A
B5243	R	A	A	R	R	A	A
B5284	R	R	A	R	R	A	A
B5222	R	A	A	A	A	A	A
B5215	A	A	A	A	A	A	A

*Reject
†Accept

CONCLUSIONS/RECOMMENDATIONS

The Truton procedure, because of the combination of angles selected and the use of a DAC form of rejection criteria, actually provides a more sensitive and conservative inspection than originally planned. It is MTL's judgment, after comparing results of the Truton procedure to those of the MTL modified procedure, that improvements can be made to the Truton procedure, but that they are considered to be discretionary in nature since experienced personnel using the Truton procedure can perform a sensitive inspection which is more likely to reject a good fitting (Error of Type I) than accept a bad fitting (Error of Type II). However, operator-to-operator differences in results are very likely with the Truton procedure.

The 45-, 55-, and 65-degree angles of the MTL procedure have been proven to be more sensitive when directly compared with the existing 50- and 60-degree angles at the same machine settings. However, when using a DAC-type rejection curve of the Truton procedure, smaller indications result in rejection of the part. Whether the indications resulting in rejection are relevant or not in terms of the actual physical condition of the part causing the signal has not been determined. All that can be said for sure is that the Truton procedure will reject more fittings and is thus more Safety-of-Flight conservative.

The MTL procedure was modified to be more sensitive by artificially adjusting the gain for the 45- and 55-degree angles a specified number of dB beyond that produced during actual calibration. As a result, the MTL procedure now is also more sensitive than originally planned, i.e., reject on a 3/64 in. size flaw, but will probably reject fewer fittings (approximately 14% less). It should provide more operator-to-operator consistency.

Overall, whether or not it is worth implementing any of the revisions into the inspection operations at this time is a decision which must be left to the PM Cobra/AVSCOM. The newly fabricated root end fittings are scheduled to begin to be phased in during the November-December 1988 time frame, eventually resulting in the elimination of this inspection requirement.

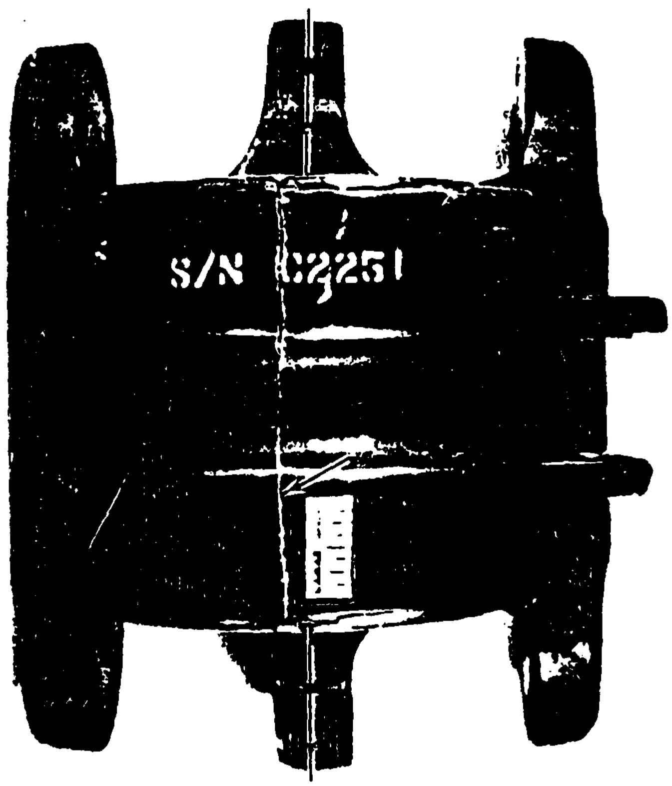


Figure 1. Root end fitting.

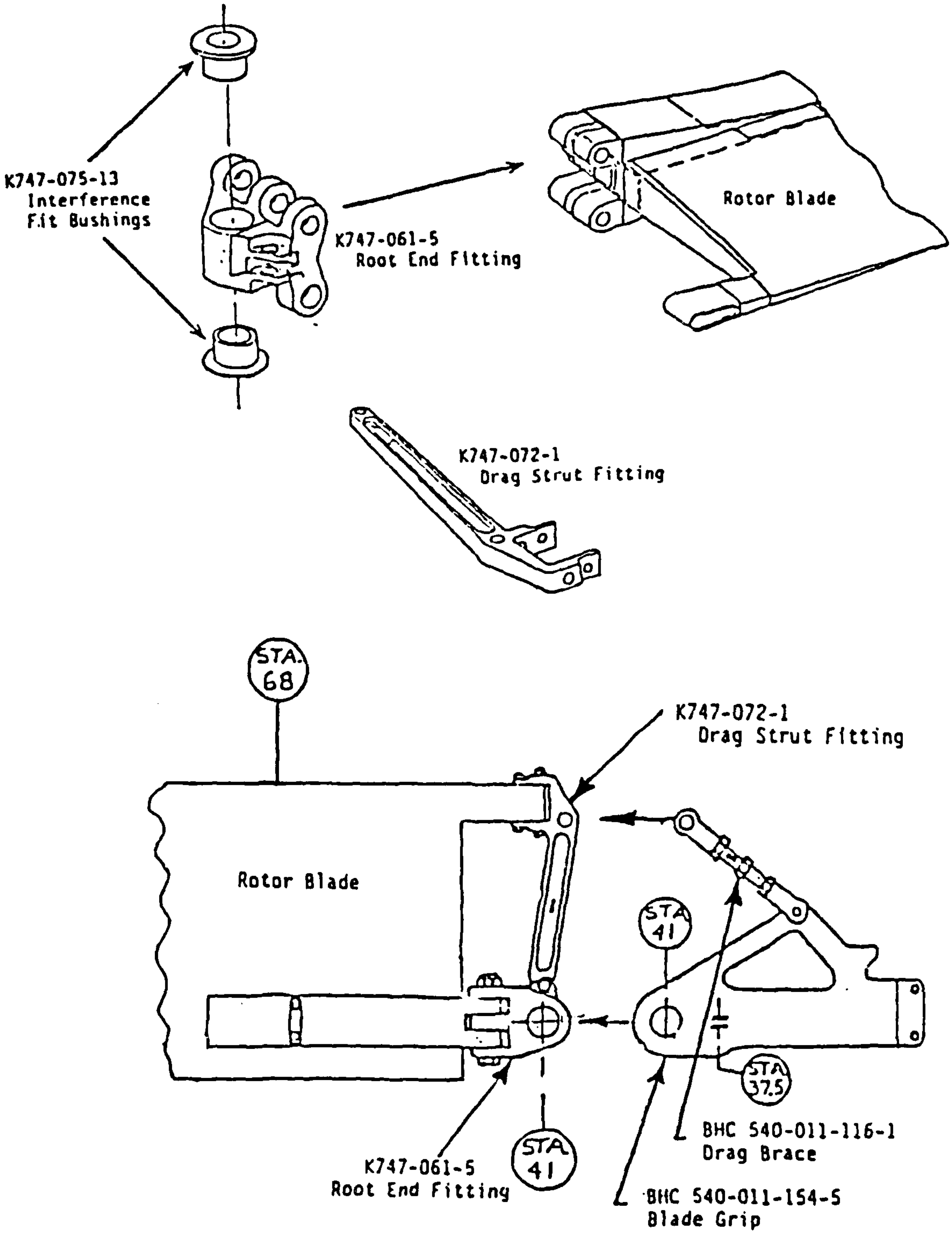


Figure 2. Root end fitting schematic.

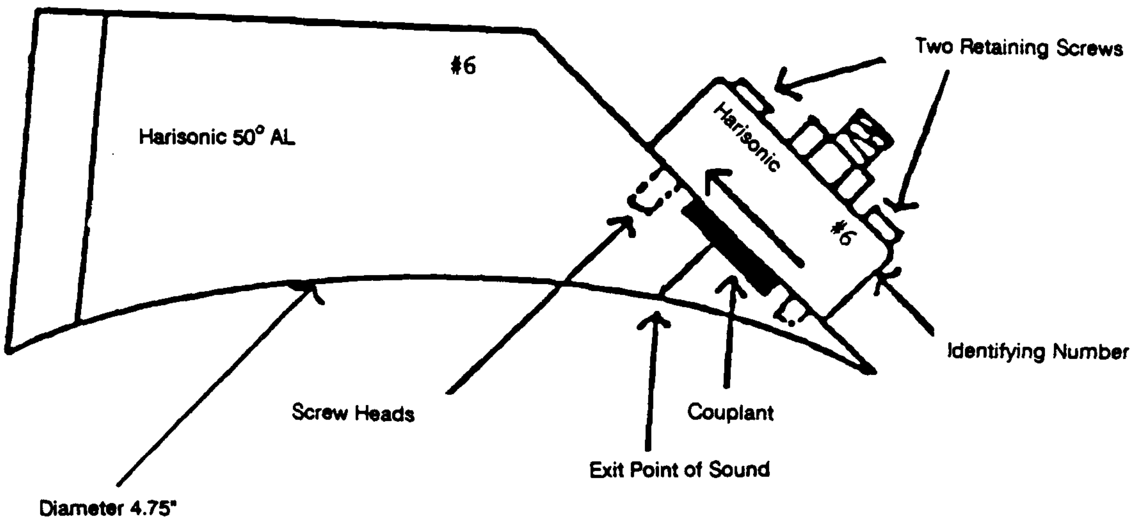


Figure 3. Truton/Aerospace's tranducer and wedge.

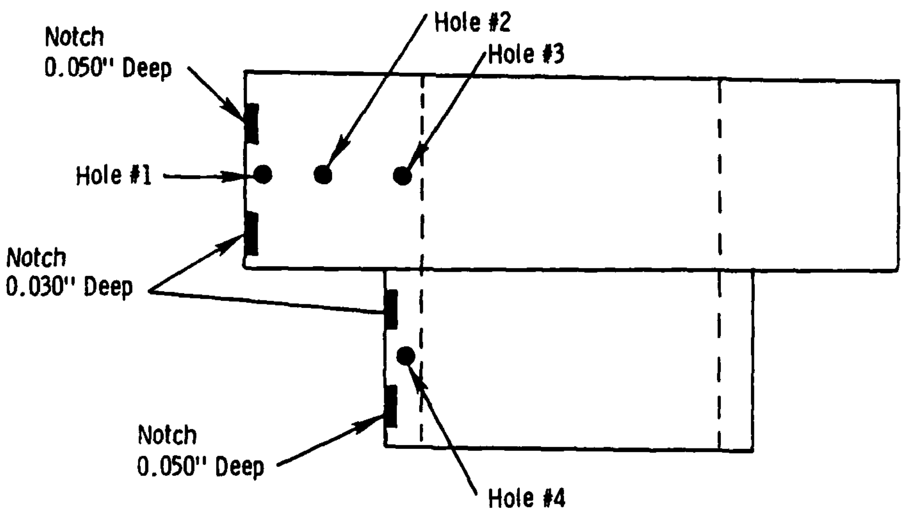


Figure 4. Truton/Aerospace's calibration standard.

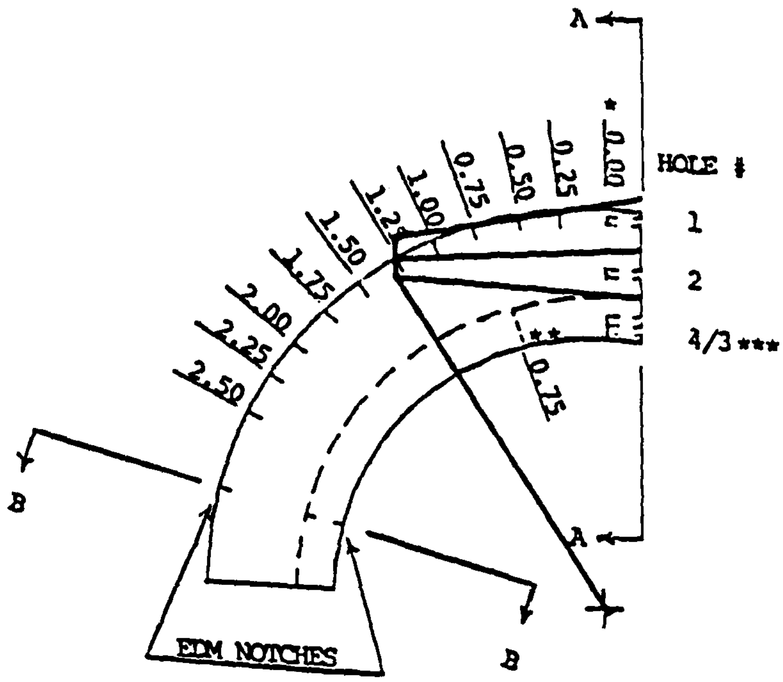


Figure 5. Sixty-degree shear wave aimed at FBH #2 from 1.25 inches.

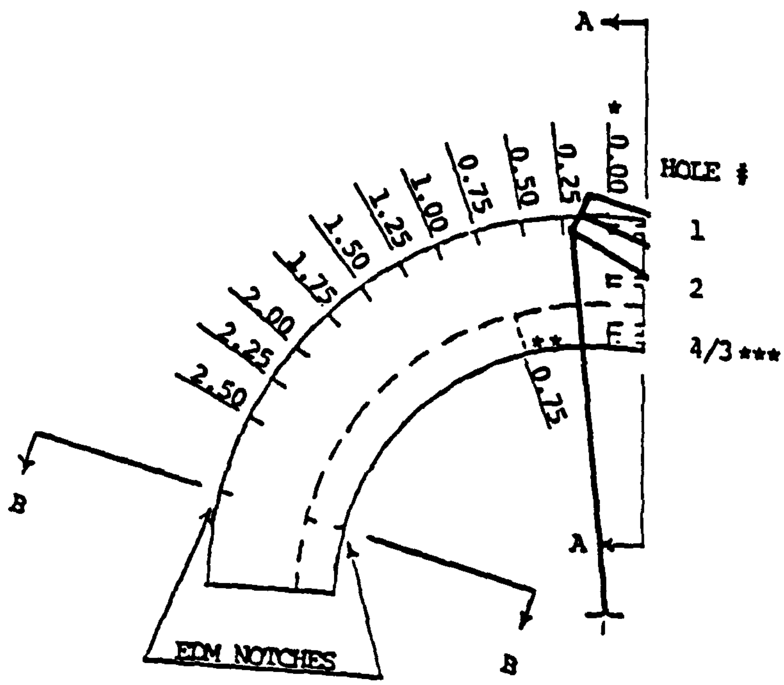


Figure 6. Sixty-degree shear wave aimed at FBH #1 from 0.25 inch.

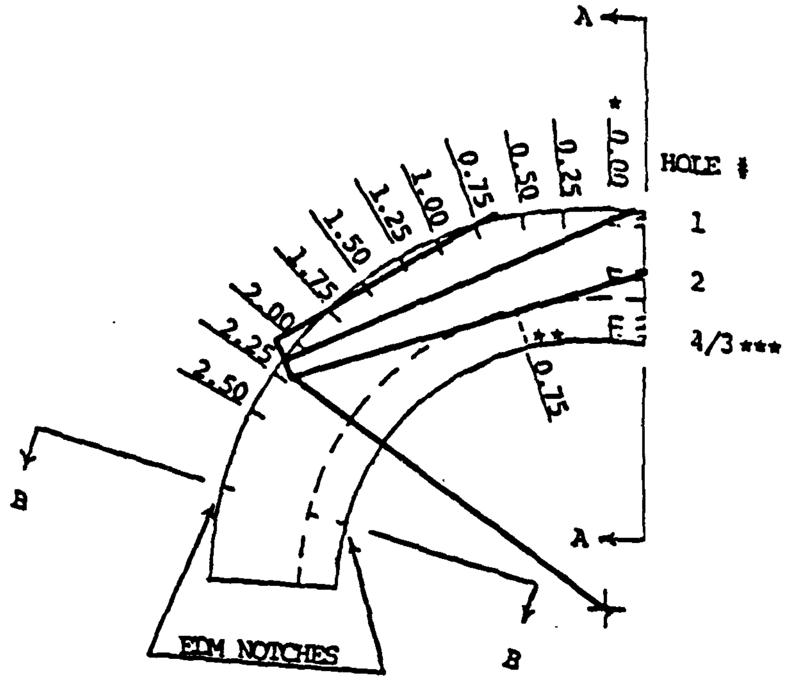


Figure 7. Sixty-degree shear wave aimed at FBH #1 from 2.125 inches.

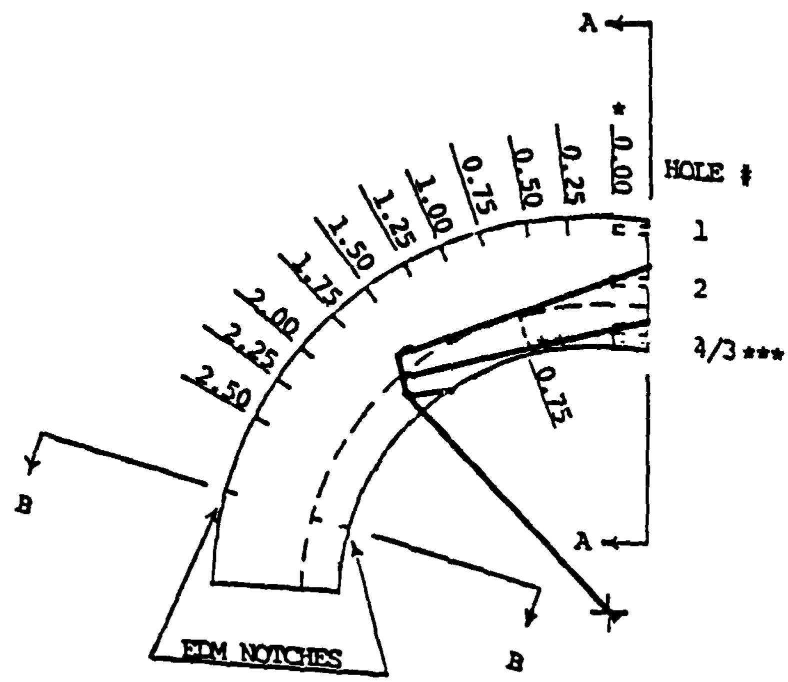


Figure 8. Sixty-degree shear wave aimed at FBH #4 from 1.75 inches.

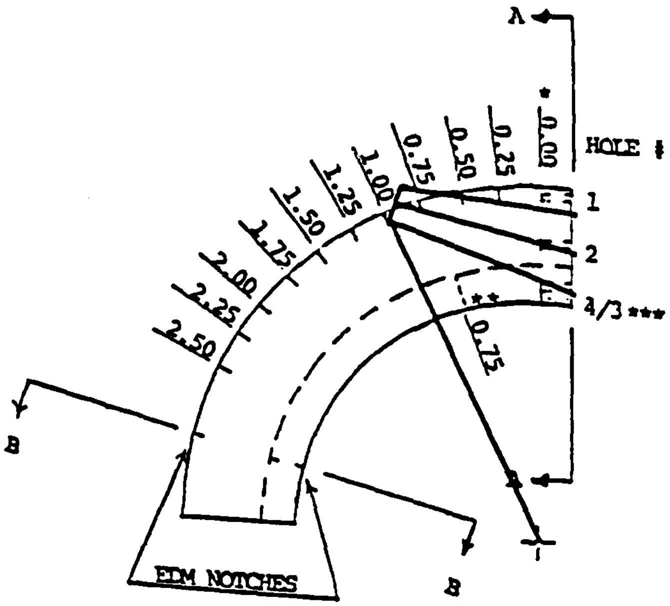


Figure 9. Fifty-degree shear wave aimed at FBH #2 from 1.00 inch.

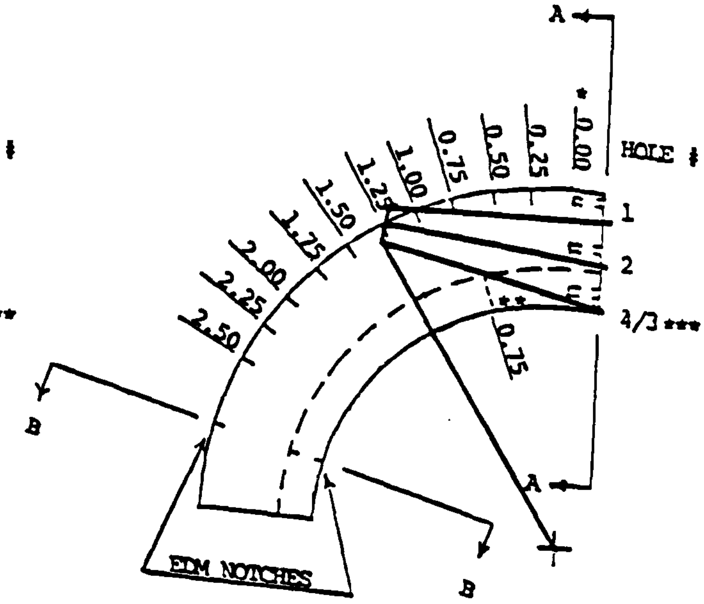


Figure 10. Fifty-degree shear wave aimed at FBH #2 from 1.25 inches.

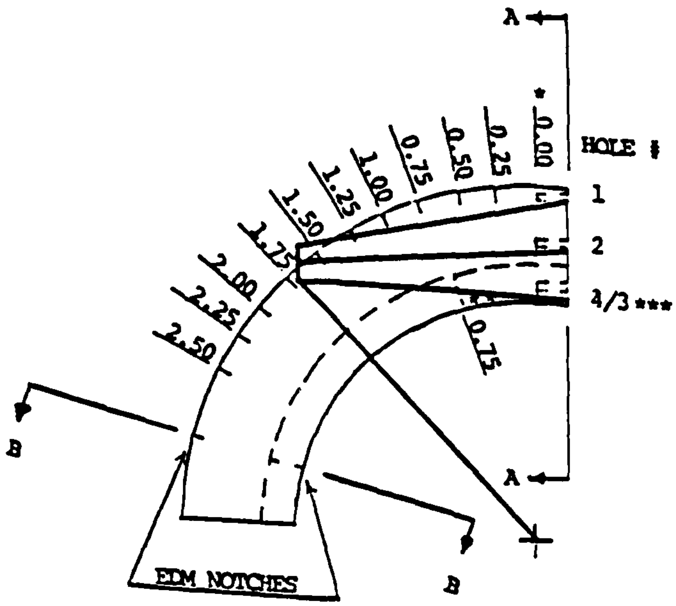


Figure 11. Fifty-degree shear wave aimed at FBH #2 from 1.625 inches.

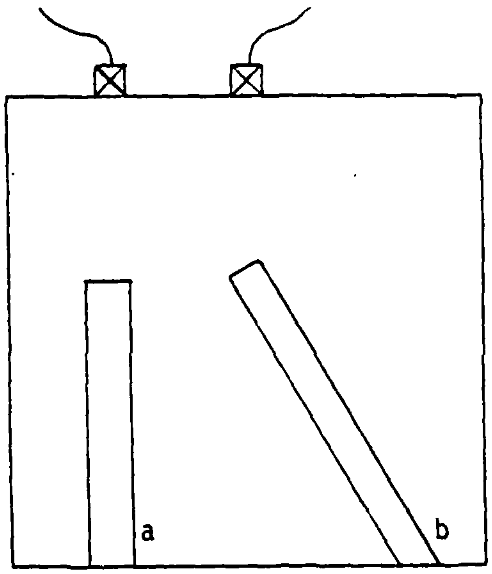


Figure 12. Parallel flat bottom holes
90 degrees to soundwave.

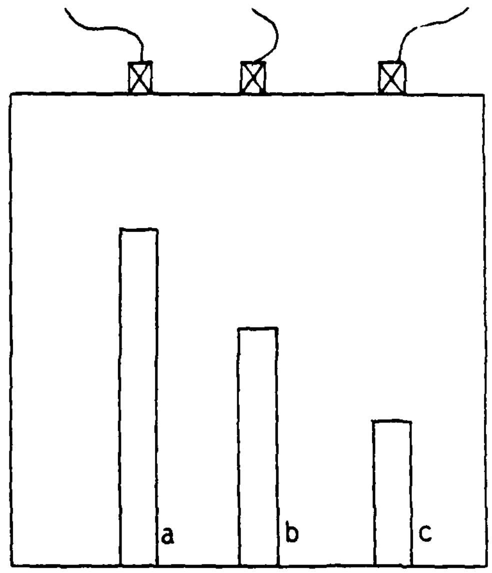


Figure 13. Nonparallel flat bottom holes.

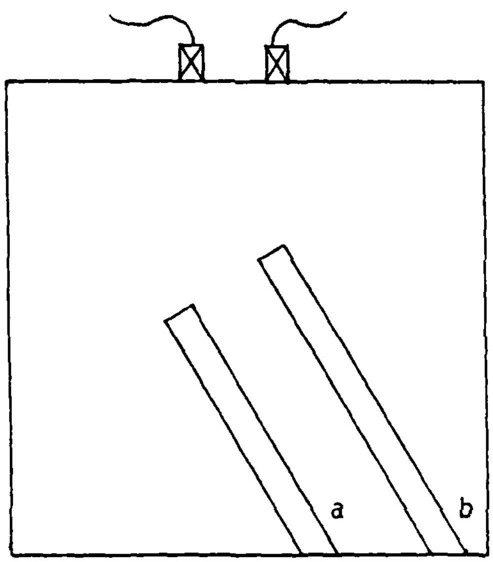


Figure 14. Parallel flat bottom holes
30 degrees to soundwave.

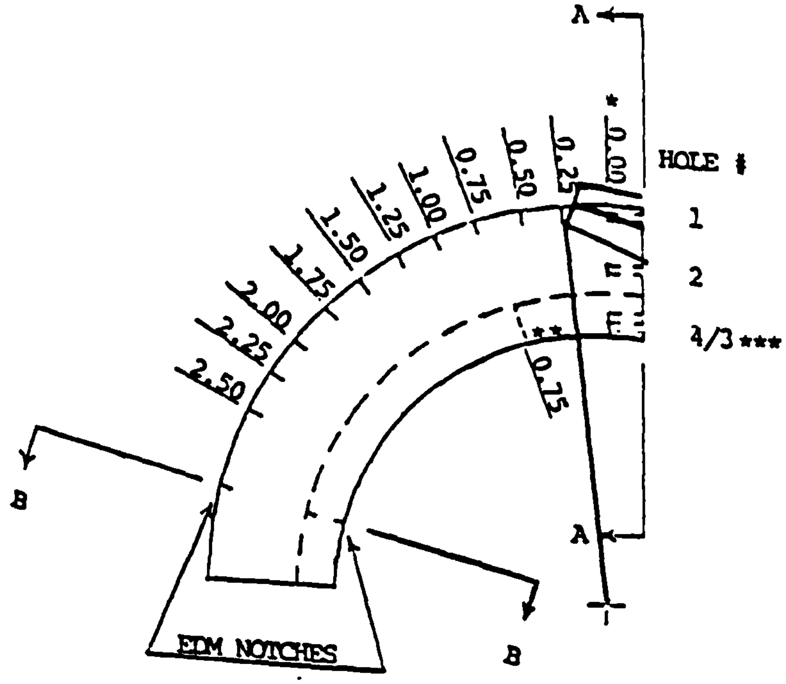


Figure 15. Sixty-five-degree shear wave aimed at FBH #1 from 0.25 inch.

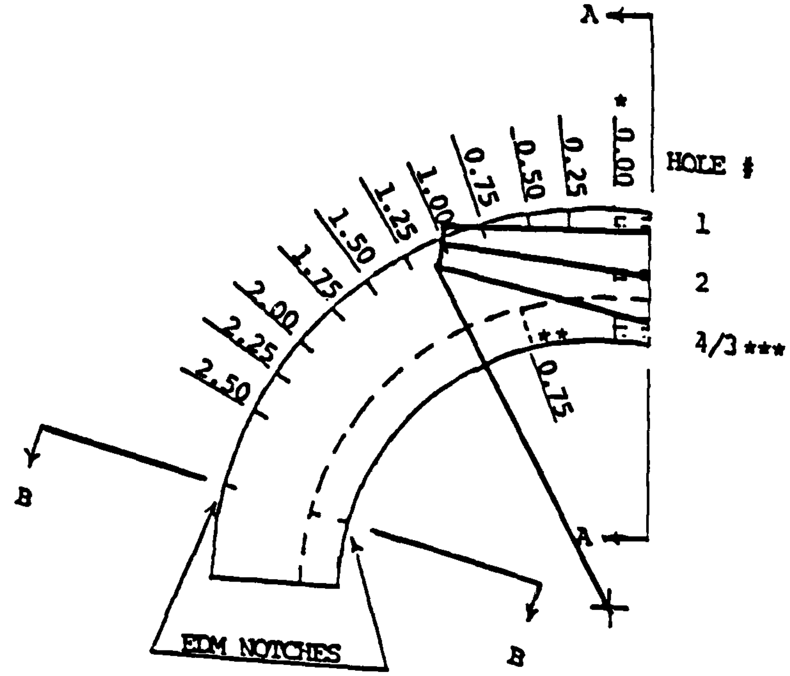


Figure 16. Fifty-five-degree shear wave aimed at FBH #2 from 1.00 inch.

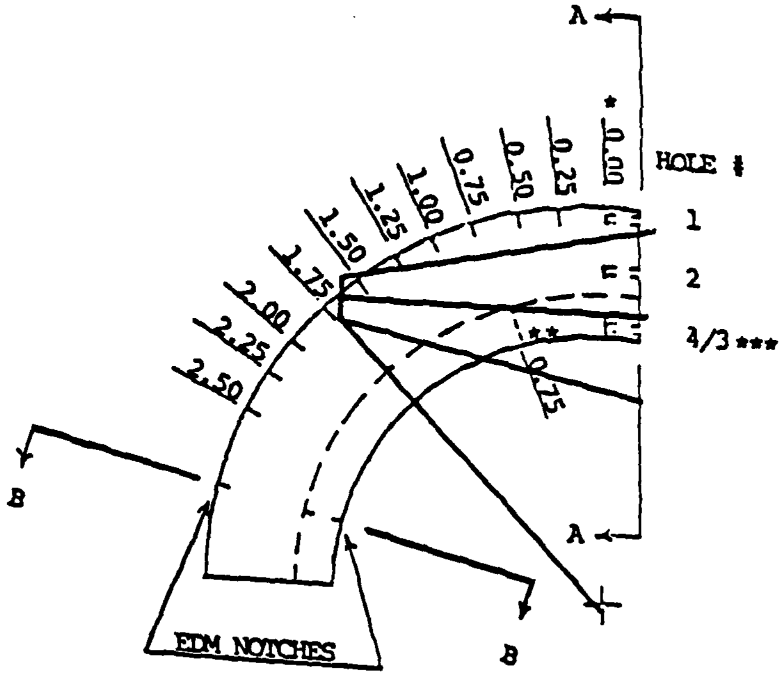


Figure 17. Forty-five-degree shear wave aimed at FBH #3 from 1.75 inches.

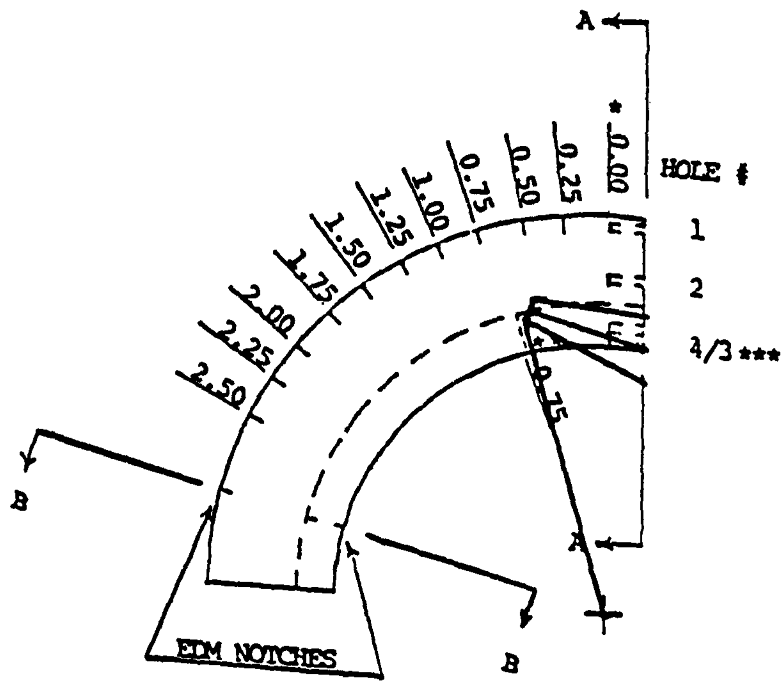


Figure 18. Sixty-seven-degree shear wave aimed at FBH #4 from 0.625 inch.

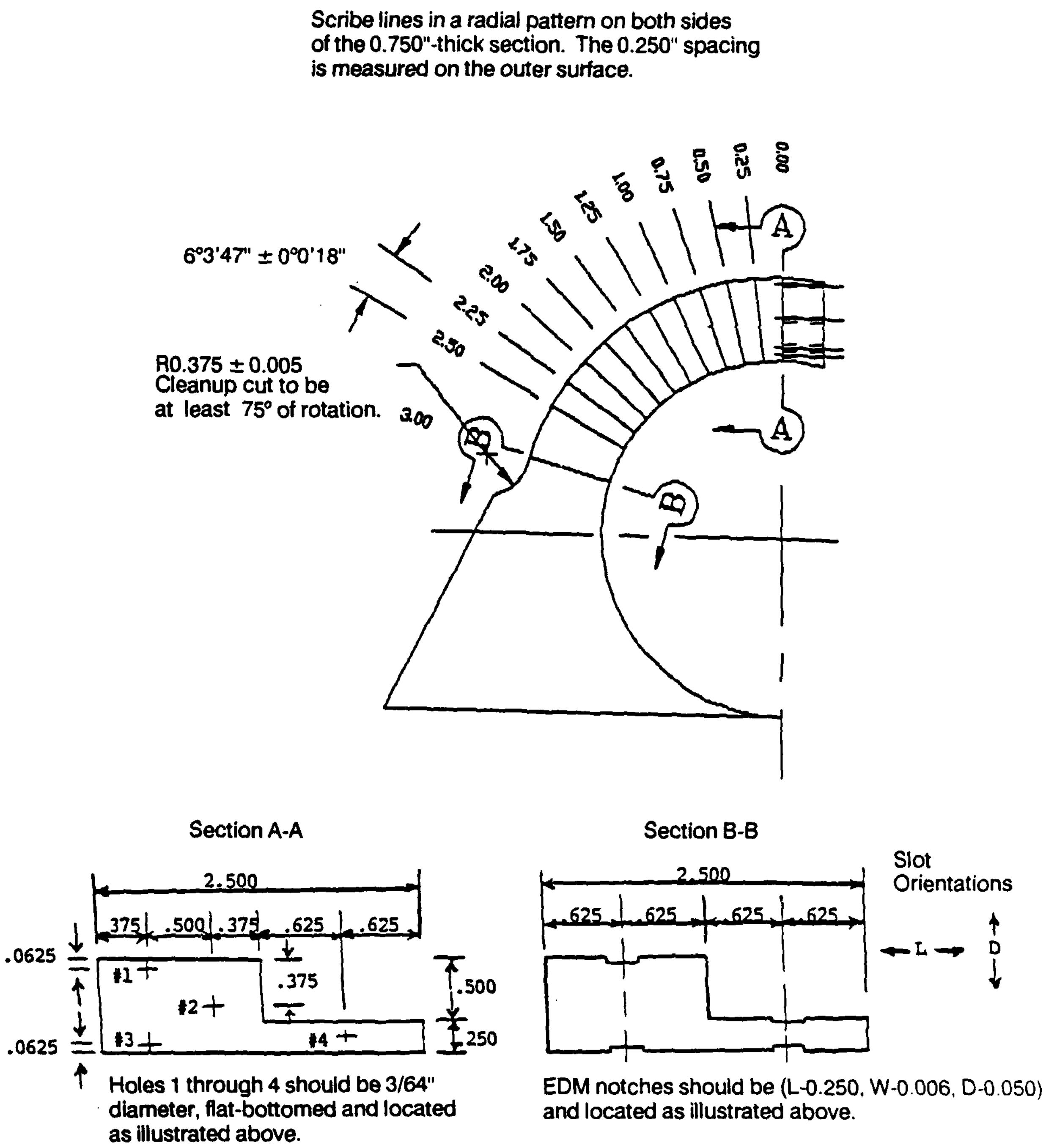


Figure 19. MTL's calibration standard.

APPENDIX I

AEROSPACE TESTING LAB, INC.

102 Skitchewaug St
Windsor CT 06095
(203) 549-6990

DATE: 1-14-88	N. Ferreira	Revision 3	Page 1 of 10

PROCEDURE
FOR
ULTRASONIC EXAMINATION OF ROOT END FITTING
PART NO. K747-061-005

Written by

Q.A. Approval

1-15-88

Kaman Approval

"CERTIFIED NONDESTRUCTIVE TESTING"

AEROSPACE TESTING LAB INC.
102 Skitchewaug Street
WINDSOR, CT 06095
(203) 549-6990

ULTRASONIC EXAMINATION OF ROOT END FITTING

TABLE OF CONTENTS

AEROSPACE TESTING LAB INC.
102 Skitchewaug Street
WINDSOR, CT 06095
(203) 549-6990

ULTRASONIC EXAMINATION OF ROOT END FITTING

1.0 SCOPE

1.1 This procedure shall be used to detect planar type discontinuities which are located in or near the parting plane of the Root-End fitting at the inboard wall of the large bore. (Refer to Figure 1)

2.0 REFERENCE

2.1 MIL-STD-2154, Ultrasonic Inspection of Wrought Metals.

2.2 MIL-STD-410, Nondestructive Examination Personnel Qualification and Certification.

2.3 KAMAN PROCESS SPECIFICATION, KPS 207 - Ultrasonic Inspection of K747-061 Root End Fitting, (Forging), (Machined), and (Finished Assembly).

Note: The purpose of this procedure is for PIN K747-061-005. Finished Root-End Fitting only.

2.4 Kaman Engineering Order, E.O. H-16 applies.

3.0 PERSONNEL

3.1 Personnel performing and evaluating to this procedure, shall be a certified Level II or III to MIL-STD-410 in Ultrasonics.

4.0 EQUIPMENT

4.1 A pulse echo type ultrasonic unit capable of generating frequencies up to 5 MHz shall be used. The equipment's linearity requirements shall meet MIL-STD-2154.

4.2 Transducers shall be 0.25" in size with frequency of 5 MHz, and equipped with shoes to transmit angle beams of 50-degree shear and 60-degree shear into the material. The shoes shall be machined to fit the curvature of the larger radius of the Root-End Fitting assembly.

<u>ULTRASONIC EXAMINATION OF ROOT END FITTING</u>

4.3 Calibration standards (P/N K747-061-005-T64) shall be of the same configuration, heat treatment and surface finish condition as the Root-End Fitting. (Excluding the black paint). (Refer to Figure 3).

4.4 Couplant shall be Ultragel II or Exosen 20. Other commercial couplant may be used provided they contain no component which may be injurious to the material.

5.0 CALIBRATION PROCEDURE

5.1 The calibration procedure outlined herein shall be performed prior to the start of testing at 4 hour intervals during testing and after the last part has been tested.

5.1.1 If any points of the DAC have decreased more than 2 Db of its amplitude since the previous calibration check, all fittings examined during that period shall be re-examined. If any points of the DAC have increased more than <u>2Db</u> of its amplitude, all recorded indications since the previous calibration check shall be re-evaluated and the values corrected on the reports.

5.1.2 Each time a calibration is performed it shall be documented on the "Calibration Data Sheet", Appendix III to this procedure. These sheets must be submitted with the ultrasonic reports.

5.2 Set the Horizontal Sweep Range of the examination by using the 60 degree probe. *Note: Distances listed herein are circumferential distances.

5.2.1 Establish the exit point by scanning on the top of the 0.030" or 0.050" deep notch. (Refer to Figure 3). Maximize the signal obtained and adjust the sweep (delay) control to set the signal at "0" screen division on the Horizontal Sweep.

5.2.2 Scan to detect the 0.050" deep notch by moving the probe to approximately 2." from the notch to the exit point of the probe. Maximize the signal obtained and adjust the range control to set the signal at the 7th major screen division on the Horizontal Sweep.

5.2.3 Repeat 5.2.1 and 5.2.2 and re-adjust the controls if necessary.

5.3 The sensitivity of the examination shall be established using a Distance Amplitude Correction (DAC) Curve as described below.

AEROSPACE TESTING LAB INC.
102 Skitchewaug Street
WINDSOR, CT 06095
(203) 549-6990

ULTRASONIC EXAMINATION OF ROOT END FITTING

5.3.1 Using the 60 degree probe, obtain a signal from the center hole #2 (probe location is approximately 1.25" from the 0.030" and 0.050" deep notch and the signal will be located (approx.) between the 4th and 5th major screen division on the Horizontal Sweep.) Maximize the signal on the #2 hole by manipulating the probe in all directions (X, Y) to obtain the highest signal amplitude and then adjust the Instrument Gain to achieve a signal of 100% Full Screen height on the Vertical Sweep. Mark the screen locations of the peak amplitude (100% Full Screen Height) on the Vertical Sweep and the position on the Horizontal Sweep.

5.3.2 Without changing the gain, obtain a signal from the top hole #1 (probe location is (approx.) 0.25" from the 0.030" and 0.050" deep notch and the signal will be located (approx.) at the 1st major screen division on the Horizontal Sweep). Maximize the signal by manipulating the probe to obtain the peak signal amplitude. Mark the location of the peak signal on the Vertical Sweep and the position on the Horizontal Sweep.

5.3.3 Obtain a signal from the top hole #1 (probe location is (approx.) 2.125" from the 0.030" and 0.050" deep notch and the signal will be located (approx.) at the 8th major screen division on the Horizontal Sweep.) Maximize the signal by manipulating the probe to obtain the peak signal amplitude. Mark the location of the peak signal on the Vertical Sweep and the position on the Horizontal Sweep. Note: This signal is obtained after the sound skips off the O.D. surface to the #1 Hole.

5.3.4 Draw a line on the scope joining the three points obtained on the Vertical Sweep. Extend this line for one additional screen division to the right. This shall be the DAC Curve reference for the 60 degree shear scan on the 0.75" thick section of the Root-End fitting.

5.3.5 For the 0.25 " section, establish a DAC by obtaining a signal from hole #4 and adjust the gain to match the height of the 0.75" DAC Curve. This shall be the DAC Curve for the 0.25" section of the Root-End Fitting.

ULTRASONIC EXAMINATION OF ROOT END FITTING

5.4.0 Using the 50 degree probe, obtain a signal from the center hole #2 (probe location is approx. 1.0" from the 0.030" and 0.050" deep notch and the signal will be located (approx.) between the 3rd and 4th major screen division on the Horizontal Sweep.) Maximize the signal on the #2 hole by manipulating the probe in all directions (X, Y) to obtain the highest signal amplitude then adjust the Instrument gain to achieve a signal of 100% Full Screen height on the Vertical Sweep. Mark the screen location of the peak amplitude (100% Full Screen Height) on the Vertical Sweep and the position on the Horizontal Sweep.

5.4.1 Without changing the gain, obtain a signal from the bottom hole #3 (probe location is approx. 1.25" from the 0.030" and 0.050" deep notch and the signal will be located (approx.) between the 4th and 5th major screen division on the Horizontal Sweep.) Maximize the signal by manipulating the probe to obtain the peak signal amplitude. Mark the location of the peak signal on the Vertical Sweep and the position on the Horizontal Sweep.

5.4.2 Obtain a signal from the center hole #2 (probe location is approx. 1.75" from the 0.030" and 0.050" deep notch and the signal will be located (approx.) at the 6th major screen division on the Horizontal Sweep. Maximize the signal by manipulating the probe to obtain the peak signal amplitude. Mark the location of the peak signal on the Vertical and the position on the Horizontal Sweep.

5.4.3 Draw a line on the scope joining the three points obtained on the Vertical Sweep. Continue this line one screen division on each end of the three points marked. This shall be the DAC Curve Reference for the 50 degree shear scan on the 0.75" thick section of the Root-End Fitting.

AEROSPACE TESTING LAB INC.
102 Skitchewaug Street
WINDSOR, CT 06095
(203) 549-6990

ULTRASONIC EXAMINATION OF ROOT END FITTING

6.0 EXAMINATION PROCEDURE AND EVALUATION PROCEDURE

6.1 The area of interest for this inspection is the forging parting plane and approximately 1/8" either side of the parting plane. (Refer to Figure 1) In order to facilitate maximum coverage of this area and to reduce the number of signals not relevant to this area the following scanning procedure shall be followed.

6.1.2 For the 3/4" thick sections, the 60 degree transducer shall be used to scan the fitting from up to the parting plane to 2-3/16" from the parting plane. (Refer to Figure 6) For the 1/4" thick section the scan shall be from up to the parting plane to 1-1/2" from the parting plane. These are circumferential distances measured from the parting plane.

6.1.3 The 50 degree transducer shall be used to scan only the 3/4 inch thick sections. The fitting shall be scanned from 1/2" from the parting plane to 2" from the parting plane. (Refer to Figure 7) These are circumferential distances measured from the parting plane.

6.2 Scanning for both angles shall include 100% of the surfaces indicated. The transducer shall be overlapped a minimum of 10% for each scan pass. The scanning shall be from both sides of the parting plane with the sound beam directed towards the parting plane. The aft side of the fitting shall be scanned only as far back as the part geometry will permit good probe contact with the part.

6.3 Scanning shall be limited to the straight surfaces only. The corners shall not be scanned as scanning in these areas will cause non-relevant indications.

ULTRASONIC EXAMINATION OF ROOT END FITTING

6.4 Scanning on the section with the smaller radius will cause surface waves which are not relevant to this exam. Indications which are found during this scan shall be checked to see if they are caused by surface waves.

6.5 Prior to scanning add 10 decibels to the calibration sensitivity established in Section 5 to this procedure. This will assure that all flaws which are possibly reportable or rejectable are detected.

6.6 All indications within the are of interest shall be maximized by probe manipulation. The indications shall then be evaluated at the reference level.

6.7 Indications outside of the DAC shall be considered non-relevant.

7.0 REPORTABLE INDICATIONS

7.1 All relevant indications with an amplitude greater than 30% shall be reported. Amplitudes of reportable indications shall be recorded as percentage of reference level. (Refer to Table I)

7.2 Reporting shall be done on Form QF 4.1.344 Rev. 2/87 (See attached sample form)

8.0 UNACCEPTABLE INDICATIONS

8.1 All relevant indications which exhibit an amplitude greater than 100% of calibration level, (MIL-STD-2154 CL-AA Single Indication of a #3 Flat Bottom Hole) shall be rejected. The segment where the indication is located shall be recorded as per Figure #2 and #5.

AEROSPACE TESTING LAB INC.
102 Skitchewaug Street
WINDSOR, CT 06095
(203) 549-6990

DATE: 1-14-88	N. Ferreira	REVISION- 3	PAGE: 9 of 10

ULTRASONIC EXAMINATION OF ROOT END FITTING

Table I
Percentage/dB Deviation from DAC

dB	%	dB	%
-20	1008	0	100
-19	899	+1	89
-18	800	+2	79
-17	713	+3	71
-16	635	+4	63
-15	565	+5	56
-14	504	+6	50
-13	449	+7	45
-12	400	+8	40
-11	356	+9	35
-10	317	+10	31
-9	283	+11	28
-8	252	+12	25
-7	224	+13	22
-6	200	+14	20
-5	178	+15	18
-4	159	+16	16
-3	141	+17	14
-2	126	+18	13
-1	112	+19	11

AEROSPACE TESTING LAB INC.
102 Skitchewaug Street
WINDSOR, CT 06095
(203) 549-6990

CALIBRATION DATA SHEET

Date____________

Probe Angle ________

Probe No. ________

Cal. Std. ________

Calibration Time

Initial	
Intermediate	
Intermediate	
Final	

Reject ________

Gain ________

Coarse ______

Fine ______

Freq. ________

Damping ________

Delay

Coarse ______

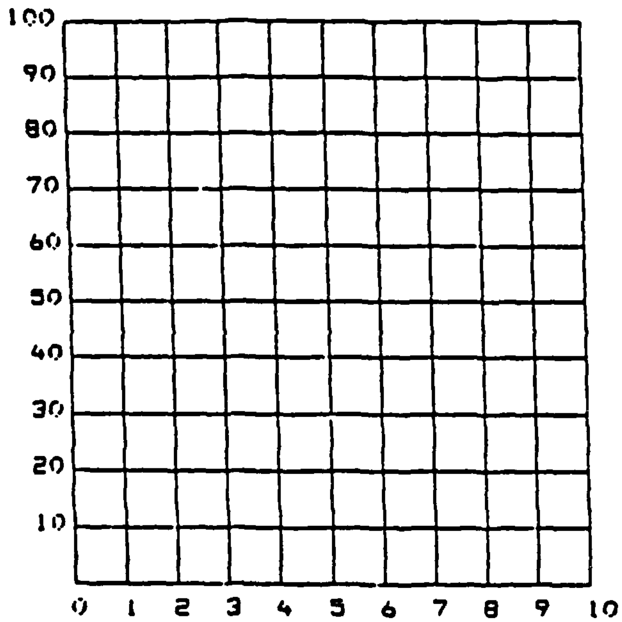
Fine ______

Range

Coarse ______

Fine ______

D.A.C. PLOT



HOLE NO.	SWEEP	AMP.

Inspector ________________

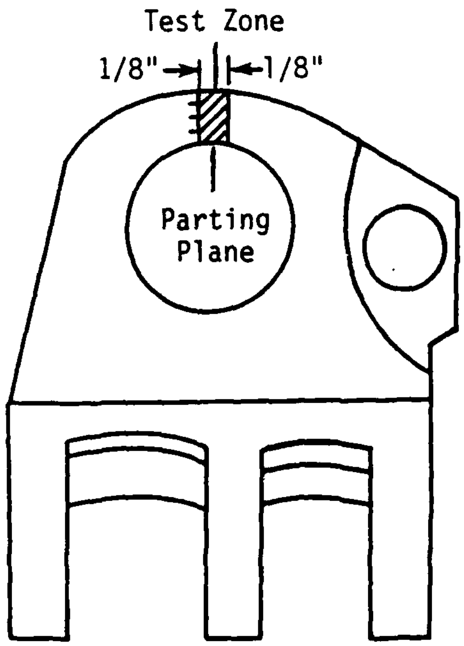


Figure 1.

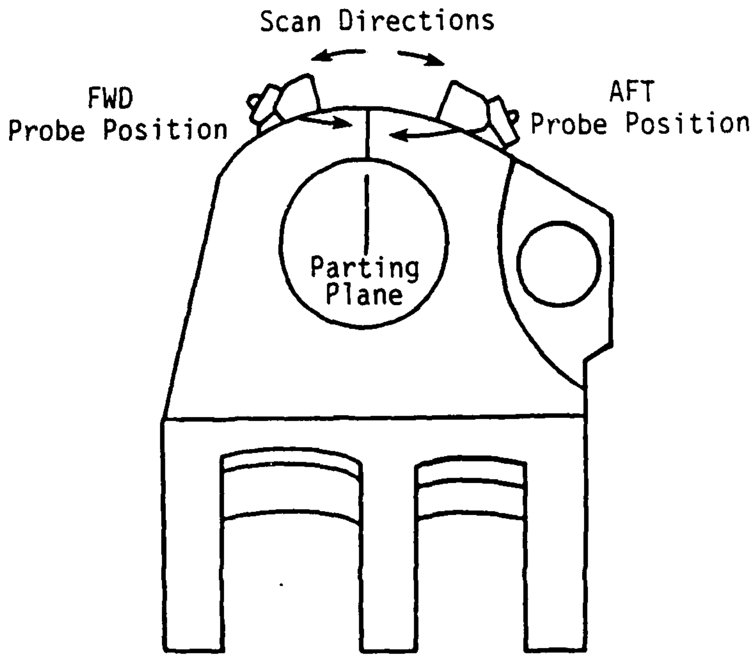


Figure 2.

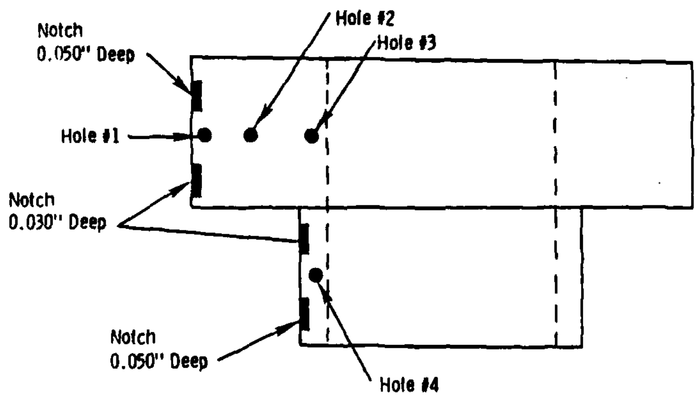


Figure 3.

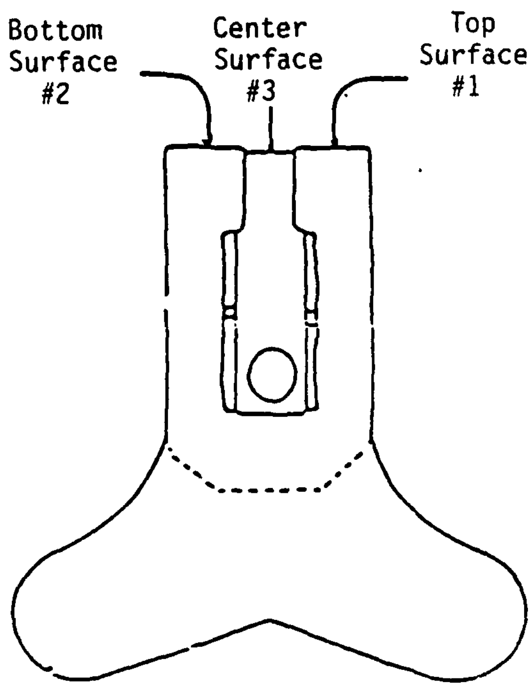


Figure 4.

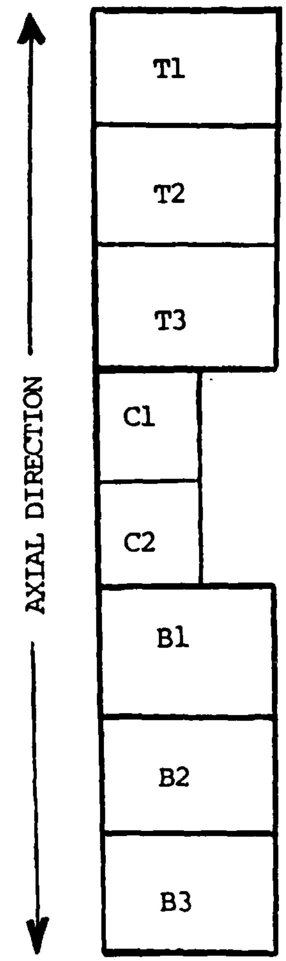


Figure 5. Identification of part segment for reporting rejectable indications.

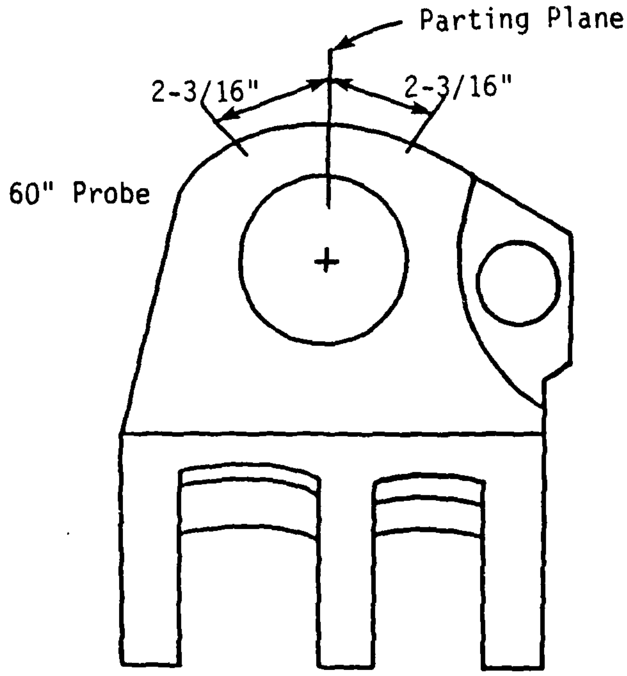


Figure 6.

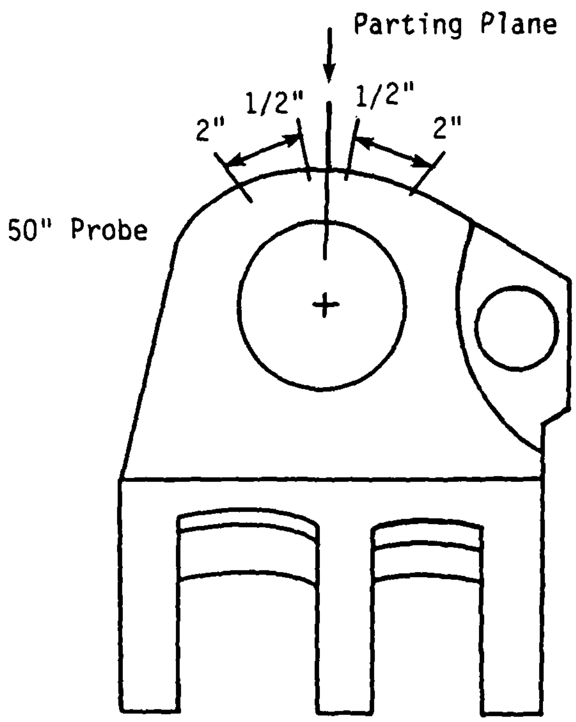
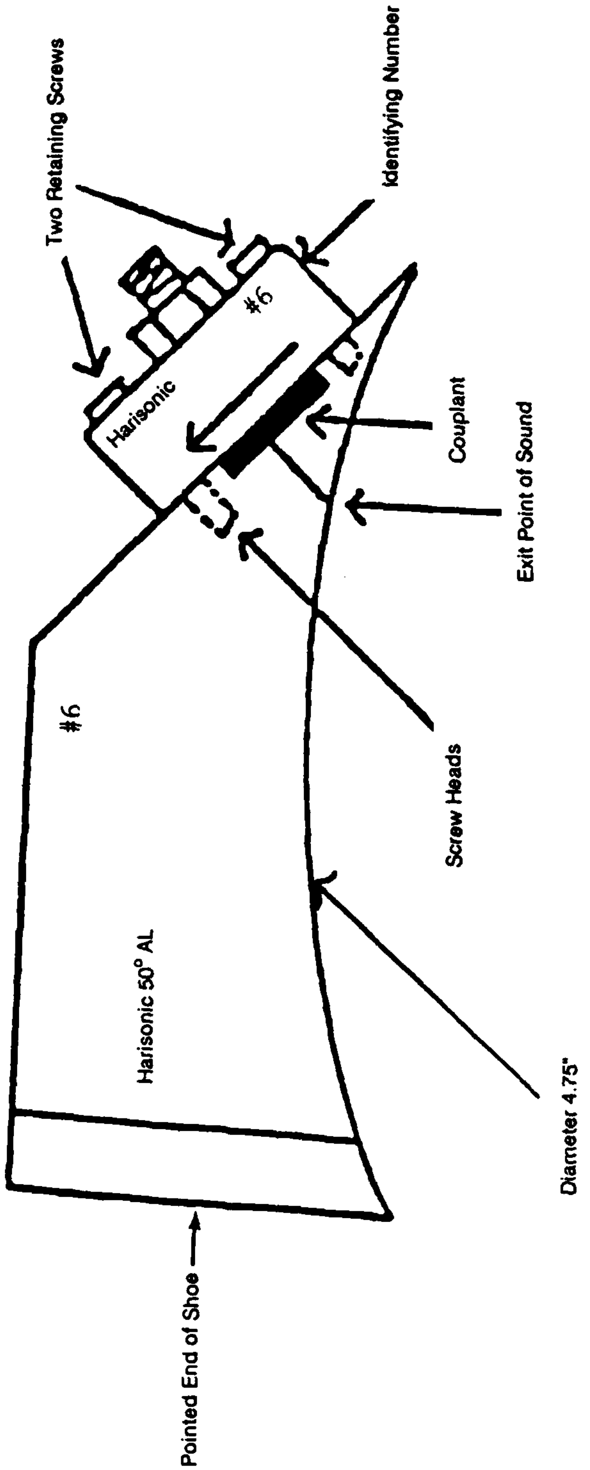


Figure 7.



Two Retaining Screws
Identifying Number
#6
Harisonic
Couplant
Exit Point of Sound
Screw Heads
#6
Harisonic 50° AL
Diameter 4.75"
Pointed End of Shoe

Addendum I.

Kaman Aerospace Corporation
P.O. Box 2
Bloomfield, CT 06002
(203) 242-4461
TELEX 9-[illegible]

KAMAN

To Whom It May Concern:

The standard you have received is serial number ___. This standard is only to be used in conjunction with 50° transducer ABM0504 serial number ___ and 60° transducer ABM0504 serial number ___. This is a matched set. All amplitudes are equal to the Kaman Aerospace master standard.

Please be advised that air can form between the transducer and the shoe. In this event, follow the steps listed below:

1. Remove the transducer from the shoe by loosening the two retaining screws.
2. Using a soft clean cloth, remove foreign material (air, loose dirt, excess couplant) from both surfaces.
3. Place couplant on transducer and shoe.
4. Locate the arrow on the transducer. Place the transducer with the arrow facing towards the pointed end of the shoe.
5. Apply light pressure on both the shoe and the transducer to remove any air that is trapped in the couplant.
6. Replace screws.

NOTE: It is important that the screws be placed straight into the holes so they do not strip the threads as they are tightened. Insert both screws until several threads are engaged. Then tighten both screws, ensuring that the transducer is squarely aligned against the shoe.

If you have any questions or problems, please feel free to call me at (203) 243-7402.

Robert Germer
Quality Control Program Manager

enc.

Appendix I.

Q.F. 4.1.344 REV 2/87

PART NUMBER K747-061-005
ULTRASONIC RESPONSE
LOG SHEET

LOCATION Ft Germer, Conn
UNIT 126th Airborne

STANDARD S/N 12
50° PROBE S/N 8
60° PROBE S/N 4

✓ = No Reportable Defects

DATE	ROOT ASSY. SERIAL NUMBER	50° SHEAR SURFACE			60° SHEAR SURFACE			SIGNATURE INSPECTOR	BLADE DASH No	BLADE S/N	ACFT S/N	FLIGHT HOURS	REMARKS
		TOP 1	BTM 2	CTR 3	TOP 1	BTM 2	CTR 3						
2-20-87	C2999	✓	✓	✓	✓	✓	✓	John Smith	-5	A3121	011	120	accept
2-20-87	C4587	✓	✓	✓	✓	✓	126%	John Smith	-7	B4711	063	39	reject
2-20-87	B3111	✓	✓	✓	AFT T2 151%	✓	✓	John Smith	-6	C1230	109	87	Indications from 100 to 151% reject
2-21-87	D4111	✓	AFT B2 126%	✓	✓	FWD B3 126%	✓	John Smith	-7	B1234	014	205	2 indications, Aft B2 - 101, 126% reject
2-21-87	4586 G	✓	✓	30%	✓	✓	75%	John Smith	-3	C2013	in box	0	accept

Completed by Joseph Doe (If other than Inspector)

Appendix II.

Q.F. 4.1.344 REV 2/87

PART NUMBER K747-061-005
ULTRASONIC RESPONSE
LOG SHEET

LOCATION ____________________

UNIT ____________________

STANDARD S/N ____________

50° PROBE S/N ____________ 60° PROBE S/N ____________

DATE	ROOT ASSY. SERIAL NUMBER	50° SHEAR SURFACE			60° SHEAR SURFACE			SIGNATURE INSPECTOR	BLADE DASH No	BLADE S/N	ACFT S/N	FLIGHT HOURS	REMARKS
		TOP 1	BTM 2	CTR 3	TOP 1	BTM 2	CTR 3						

Completed by ______________________ (If other than Inspector)

APPENDIX II. ULTRASONIC INSPECTION PROCEDURE FOR KAMAN ROOT END FITTING PART NUMBER K747-061-005

1.0 Scope

1.1 This is an ultrasonic inspection procedure for Kaman Aerospace Corporation's K747-061-005 Root End Fitting. It shall be used to detect planar type discontinuities which are located in or near the parting plane of the fitting at the inboard wall of the large bore.

2.0 References

2.1 MIL-STD-2154, Ultrasonic Inspection of Wrought Metals.

2.2 MIL-STD-410, Nondestructive Examination Personnel Qualification and Certification.

3.0 Personnel

3.1 Personnel inspecting and evaluating with this procedure shall be certified to level II or higher in Ultrasonics IAW MIL-STD-410.

4.0 Equipment

4.1 A pulse echo ultrasonic unit capable of generating frequencies up to 5 MHz shall be used. The equipment's linearity capabilities shall meet the requirements of MIL-STD-2154.

4.2 A probe consists of a transducer and wedge. They shall conform to the following chart:

Wedge Angle (Degrees)	Wedge Contour Diameter (Inches)	Transducer Size (Inches)	Transducer Frequency (MHz)
45	4.75	0.250	5
55	4.75	0.250	5
65	4.75	0.250	5
67	3.75	0.1875	5

4.3 Calibration standards (Figure II-1) shall be of the same material, configuration, heat treatment and surface finish as the root end fittings. Black paint shall be excluded.

4.4 Couplant shall be Ultragel II, Exosen 20, or any other commercial couplant that will not be harmful to the root end fitting.

5.0 Calibration Procedure

5.1 The calibration procedure described in the following paragraphs shall be performed prior to the inspections done each day. The results shall be verified at least once every 4 hours and after the last fitting has been inspected for the day.

5.1.1 If any calibration point has decreased in amplitude by more than 2 dB since the previous verification, all fittings inspected during that period shall be re-inspected. If any calibration points have increased in amplitude by more than 2 dB, all recorded indications since the previous verification shall be re-evaluated and the values corrected on the inspection data log sheet.

5.1.2 After a calibration is performed, it shall be recorded on the calibration data log sheet in Appendix I. The times of the initial calibration, intermediate calibration check, and final calibration check shall also be recorded.

5.2 The horizontal sweep will be established by using the 65-degree probe and the notches on the 0.75-inch-thick section of the standard.

5.2.1 Scan over the top of the notch to establish the beam exit point. Maximize the signal and adjust the delay until the beginning of the indication is at the 0 division on the horizontal scale.

5.2.2 Move the probe back a circumferential distance of approximately 1.75 inches and scan to detect the same notch. Maximize the signal, and adjust the range until the beginning of the indication is at 7 divisions on the horizontal scale.

5.2.3 The range and delay will slightly affect each other when they are adjusted, therefore, it may be necessary to repeat steps 5.2.1 and 5.2.2 several times until the indications are seen exactly at 0 and 7 divisions on the horizontal scale.

5.3 The sensitivity of the examination is established using defect rejection levels. They are determined by scanning the flat-bottom holes (FBHs) with the different probes at different distances and adjusting the gain until the indications are equal to or just greater than 80% screen height.

5.3.1 Using the 65-degree probe, locate the beam exit point on the transducer wedge by scanning over the top of the notch on the 0.75-inch section of the calibration standard. Use this as a reference point when measuring the FBH to probe distance. Scan at approximately 0.25-inch back from the bottom of FBH #1 (Figure II-2) to obtain a signal at approximately 1 division on the horizontal scale. Maximize the signal by manipulating the probe, and adjust the gain so that the amplitude is equal to or just greater than 80% screen height. Mark the screen at this peak, and draw a line a length of 1.0 division to the left and 1.5 divisions to the right of this point parallel to the base line. Subtract 3 dB from the gain setting. This will be the rejection threshold gain setting. Record this gain setting, the horizontal and vertical positions, and circumferential distance from the parting line on the calibration data log sheet. To ensure top surface inspection capability, face the probe toward the top surface notch, and scan from a distance of approximately 1.75 inches.

5.3.2 Using the 55-degree probe, locate the beam exit point on the transducer wedge by scanning over the top of the notch on the 0.75-inch section of the calibration standard. (NOTE: The delay will have to be adjusted to see the indication. Make sure that it is returned to its original position immediately afterwards.) Use this as a reference point when measuring the FBH to probe distance. Scan at approximately 1.0 inch back from the bottom of FBH #2 (Figure II-3) to obtain a signal at approximately 3.5 divisions on the horizontal scale. Maximize the signal by manipulating the probe, and adjust the gain so that the amplitude is equal to or just greater than 80% screen height. Mark the screen at this peak, and draw a line 1.5 divisions in length on each side of this point parallel to the base line. Add 8 dB to the gain setting. This will be the rejection threshold gain setting. Record this gain setting, the horizontal and vertical positions, and circumferential distance from the parting line on the calibration data log sheet.

5.3.3 Using the 45-degree probe, locate the beam exit point on the transducer wedge by scanning over the top of the notch on the 0.75-inch section of the calibration standard. (NOTE: The delay will have to be adjusted to see the indication. Make sure that it is returned to its original position immediately afterwards.) Use this as a reference point when measuring the FBH to probe distance. Scan at approximately 1.75 inches back from the bottom of FBH #3 (Figure II-4) to obtain a signal at approximately 5.75 divisions on the horizontal scale. Maximize the signal by manipulating the probe, and adjust the gain so that the amplitude is equal to or just greater than 80% screen height. Mark the screen at this peak, and draw a line 1.5 divisions in length on each side of this point parallel to the base line. Add 20 dB to the gain setting. This will be the rejection threshold gain setting. Record the gain setting, horizontal and vertical positions, and circumferential distance from the parting line on the calibration data log sheet. To ensure bottom surface inspection capability, face the probe toward the bottom surface notch, and scan from a distance of approximately 1.5 inches.

5.3.4 Using the 67-degree probe, locate the beam exit point on the transducer wedge by scanning over the top of the notch on the 0.25-inch section of the calibration standard. Use this as a reference point when measuring the FBH to probe distances. Scan at approximately 0.625 inch back from the bottom of FBH #4 (Figure II-5) to obtain a signal at approximately 2.5 divisions on the horizontal scale. Maximize the signal by manipulating the probe, and adjust the gain so that the amplitude is equal to or just greater than 80% screen height. Mark the screen at this peak, and draw a line toward the left to the 0 division line and an equal distance (approximately 2.5 divisions) to the right parallel to the base line. Record the gain setting, horizontal and vertical positions, and circumferential distance from the parting line on the calibration data log sheet. To ensure top and bottom surface inspection capabilities, face the probe first toward the top surface notch, and scan from a distance of approximately 1.2 inches, then toward the bottom surface notch, and scan from a distance of approximately 0.8 inch.

5.3.5 The previous paragraphs can be summarized in the following chart:

Wedge Angle (Degrees)	Calib Std Section (Inches)	FBH #	Approx Dist From FBH Bot (Inches)	Approx Pos on Horiz Scale (Divisions)	Ampl Cor Fac (dB)
65	0.75	1	0.25	1	-3
55	0.75	2	1.0	3.5	+8
45	0.75	3	1.75	5.75	+20
67	0.25	4	0.625	2.5	0

6.0 Inspection Procedure

6.1 All scanning will be done with a 6 or more dB gain increase. (The scanning increase is over and above the amplitude correction factor and should not be confused with it.) The gain increase must be removed before evaluating the indications. Inspections will be accomplished from both forward and aft locations with the probe always facing the parting line (Figure II-6). Scanning will be done in a circumferential direction with axial indexing with at least 10% overlap. All required data shall be recorded on the inspection data log sheet in Appendix II.

6.2 Using the 65-degree probe, scan the width of the top and bottom 0.75-inch sections between the parting plane and 0.625-inch circumferential distance from the parting plane. Evaluate only those indications occurring between 0 and 2.5 divisions on the horizontal scale.

6.3 Using the 55-degree probe, scan the width of the top and bottom 0.75-inch sections between 0.625 and 1.375 inches circumferential distance from the parting plane. Evaluate only those indications occurring between 2 and 5 divisions on the horizontal scale.

6.4 Using the 45-degree probe, scan the width of the top and bottom 0.75-inch sections between 1.375 and 2.125 inches circumferential distance from the parting plane. Evaluate only those indications occurring between the 4.25 and 7.25 divisions on the horizontal scale.

6.5 Using the 67-degree probe, scan the width of the 0.25-inch section between the parting plane and 1.25 inches circumferential distance from the parting plane. Evaluate only those indications occurring between 0 and approximately 5 divisions on the horizontal scale. Surface waves will sometimes be generated during this part of the inspection. If suspected, they may be damped by placing your finger on the fitting in front of the probe while scanning.

6.6 The previous paragraphs can be summarized in the following chart:

Wedge Angle (Degrees)	Ref Section (Inches)	Approx Dist From Prt Pln (Inches)	Approx Pos on Horiz Scale (Divisions)
65	0.75	0 - 0.625	0 - 2.5
55	0.75	0.625 - 1.375	2 - 5
45	0.75	1.375 - 2.125	4.25 - 7.25
67	0.25	0 - 1.25	0 - 5

7.0 Evaluating and Reporting

7.1 All relevant indications with an amplitude equal to or greater than 30% of the defect rejection level shall be reported on the inspection data log sheet (Appendix II). This percentage may be found with a calculator by dividing the amplitude of the reflection by the rejection level above or below the point. If the reflection is off screen, the dB gain can be decreased until the reflection is equal to the rejection level. The percentage may be found by using the chart in Figure II-7. The location conventions of the root end fitting segments are illustrated in Figure II-6.

7.2 All relevant indications with an amplitude greater than 100% of the established rejection level, (MIL-STD-2154 CL-AA Single Indication of a #3 Flat Bottom Hole) shall be cause for the fitting to be rejected.

7.3 All rejected fittings shall be red tagged and brought to the attention of the maintenance officer in charge of the aircraft or other authorized personnel.

7.4 The aircraft log books and historical records shall be updated after each inspection.

7.5 Copies of the inspection data log sheets and calibration data log sheets shall be submitted to: Commander, AVSCOM, Attn: AMCPM-CO-L (Mayola Andrews), St. Louis, MO 63120-1798, and to: Kaman Aerospace Corporation, PO Box 2 (Robert Germer), Bloomfield, CT 06002-0002.

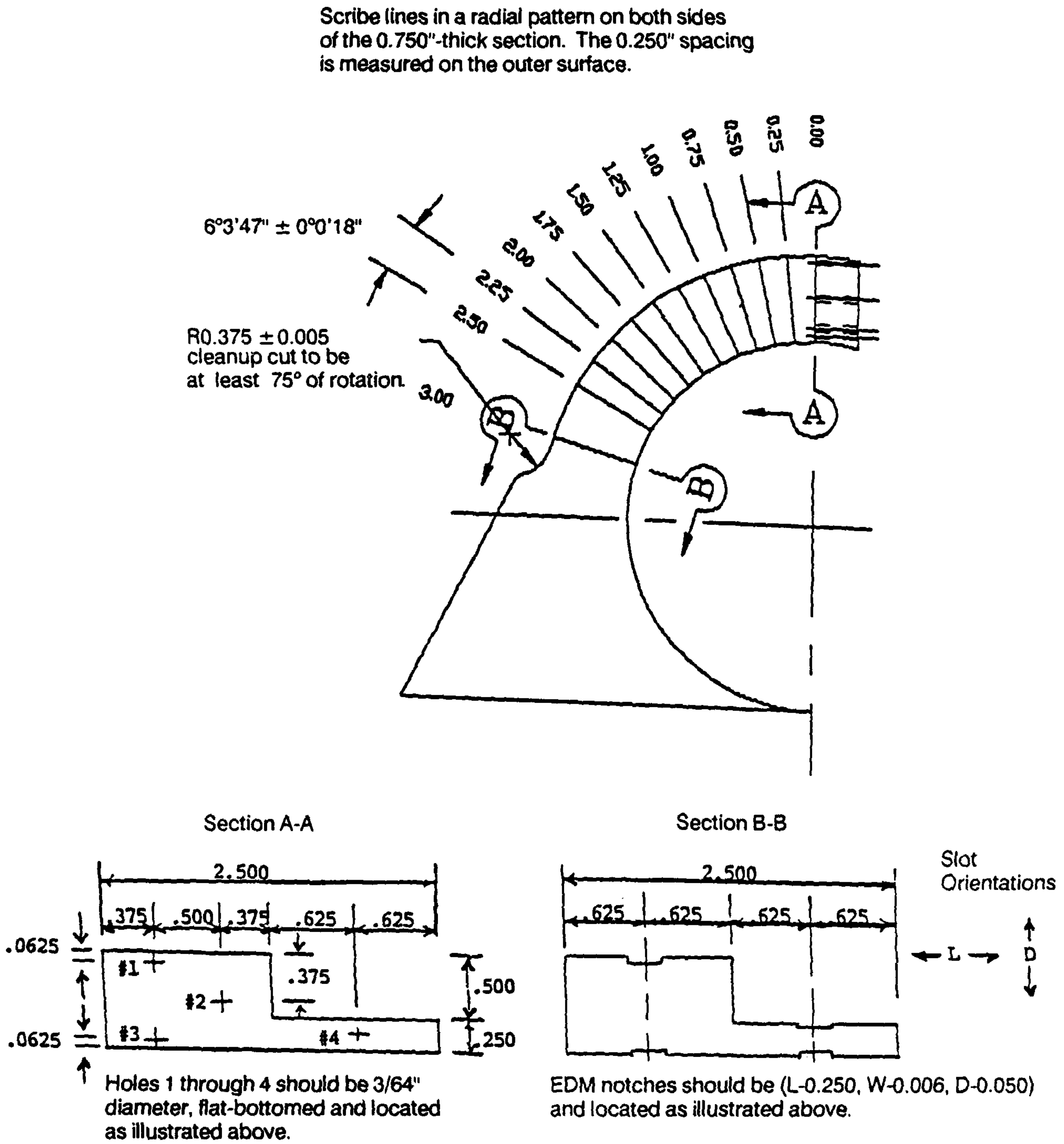


Figure II-1. Calibration standard.

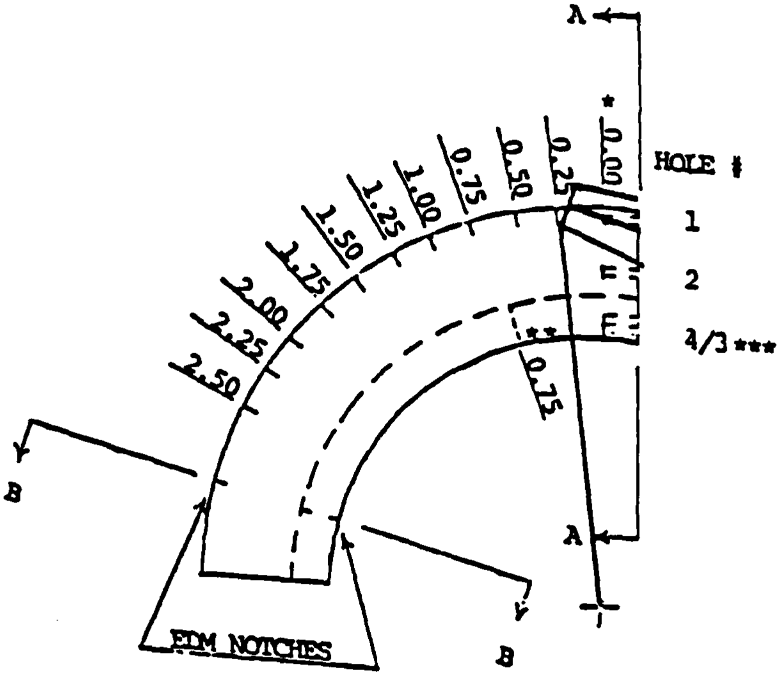


Figure II-2. Sixty-five-degree shear wave aimed at FBH #1 from 0.25 inch.

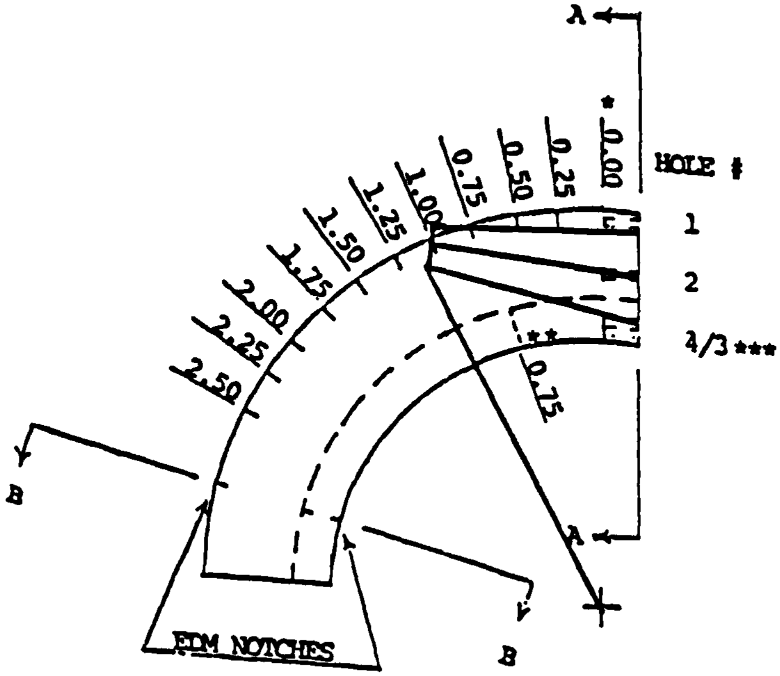


Figure II-3. Fifty-five-degree shear wave aimed at FBH #2 from 1.00 inch.

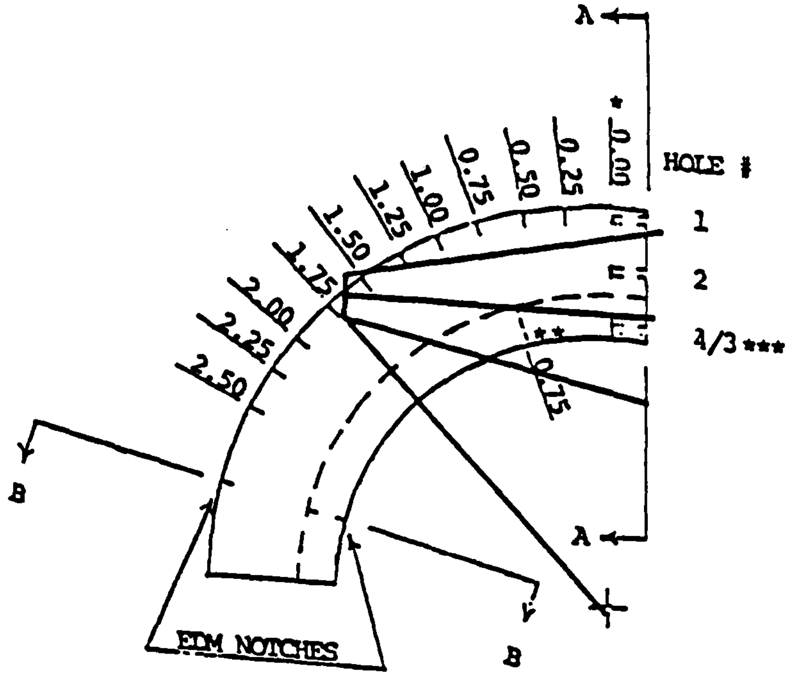


Figure II-4. Forty-five-degree shear wave aimed at FBH #3 from 1.75 inches.

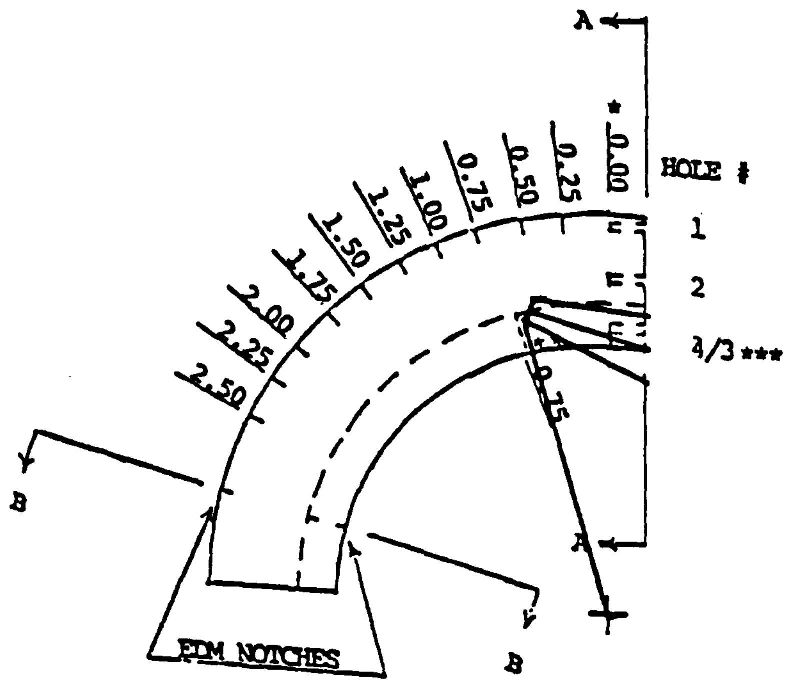


Figure II-5. Sixty-seven-degree shear wave aimed at FBH #4 from 0.625 inch.

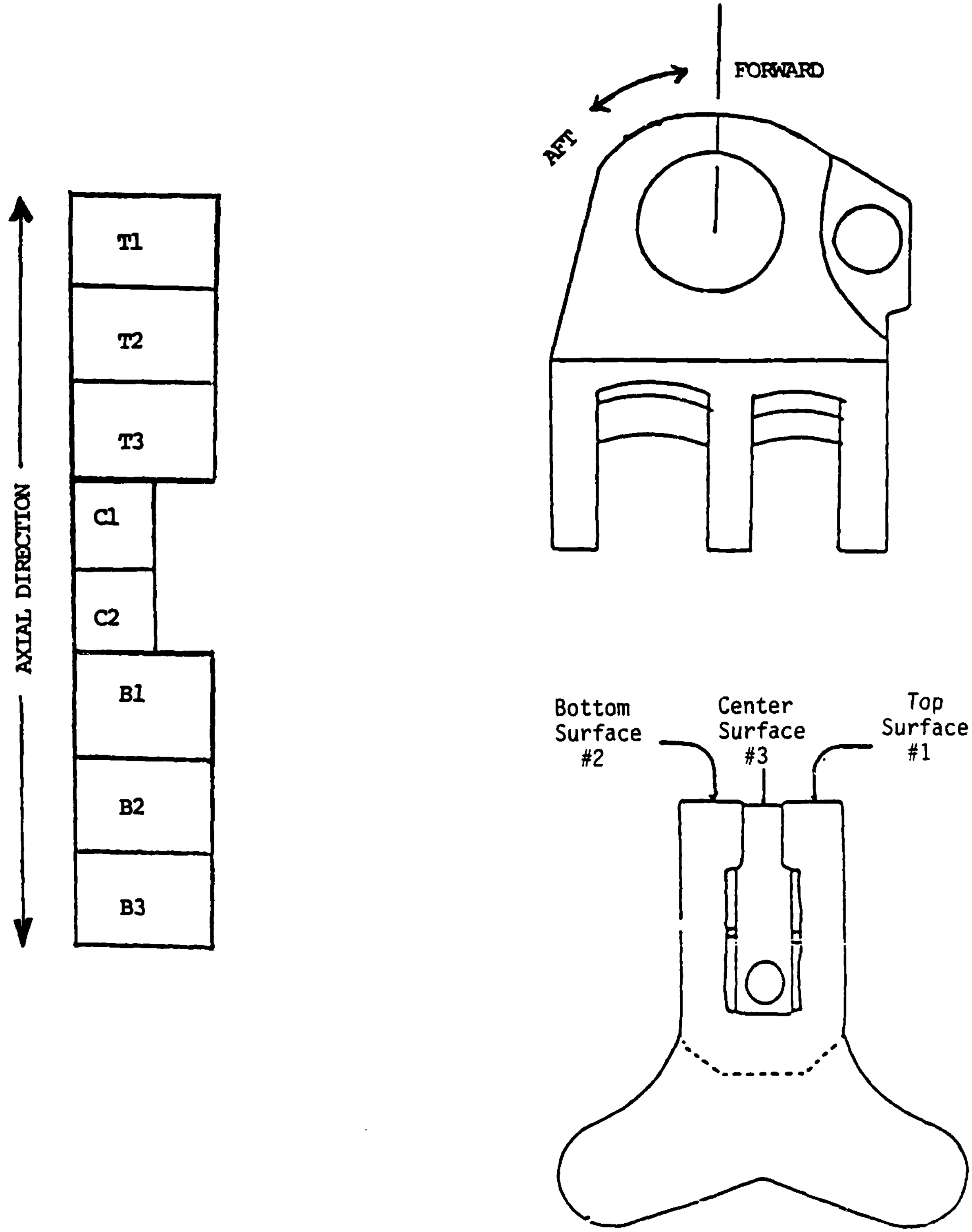


Figure II-6. Location conventions.

Percentage/dB Deviation from DAC

dB	%	dB	%
-20	1008	0	100
-19	899	+ 1	89
-18	800	+ 2	79
-17	713	+ 3	71
-16	635	+ 4	63
-15	565	+ 5	56
-14	504	+ 6	50
-13	449	+ 7	45
-12	400	+ 8	40
-11	356	+ 9	35
-10	317	+10	31
- 9	283	+11	28
- 8	252	+12	25
- 7	224	+13	22
- 6	200	+14	20
- 5	178	+15	18
- 4	159	+16	16
- 3	141	+17	14
- 2	126	+18	13
- 1	112	+19	11

Figure II-7. dB chart.

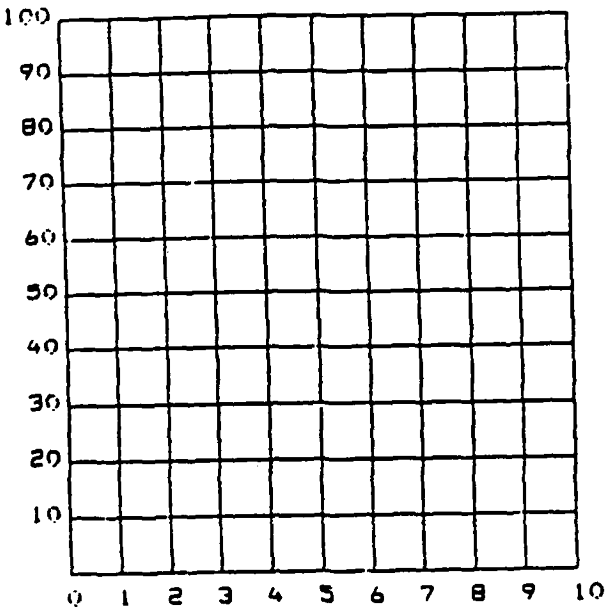
Appendix I.

CALIBRATION DATA LOG SHEET

Location ____________________ Unit ____________________

Date	__________	Reject	__________
Initial Time	__________	Damping	__________
Intermediate	__________	Delay	
Intermediate	__________	Coarse	__________
Final Time	__________	Fine	__________
		Range	
Calibration Standard		Coarse	__________
____________________		Fine	__________

FBH #	Probe Angle	Probe Number	Gain	Sweep	Ampl.	Dist.
___	_____	_____	_____	_____	_____	_____
___	_____	_____	_____	_____	_____	_____
___	_____	_____	_____	_____	_____	_____
___	_____	_____	_____	_____	_____	_____



NOTES:

Inspector ____________________

Appendix II.

ULTRASONIC INSPECTION REPORT
PART NUMBER K747-061-005

LOCATION ____________ UNIT ____________ STANDARD S/N ____________

DATE	ROOT ASSY. SERIAL NUMBER	45° SHEAR SN: SURFACE		50° SHEAR SN: SURFACE		60° SHEAR SN: SURFACE		67° SHEAR SN: SURFACE	SIGNATURE INSPECTOR	REMARKS
		TOP	BTM	TOP	BTM	TOP	BTM	CTR		

APPENDIX III. TRANSDUCER WEDGE ANGLE DATA RESULTS

No Procedure, Gain = 70 dB
45-Degree Probe

REF#	TF1	TF2	TF3	TA1	TA2	TA3	BF1	BF2	BF3	BA1	BA2	BA3
B5328	37 41	35 38	-	-	-	-	48 50	34 38	-	-	-	-
B5102	46	40	35	-	-	-	32	34 37	30	-	-	-
B5298	52 62	44 55	31 38	-	-	-	36 44	35 42	52 53	-	-	-
B4994	-	-	-	-	-	-	31 34	36 38	32 55	-	-	-
B5227	-	-	-	-	-	-	31 39	41	31	-	-	-
B4906	-	-	-	-	-	-	-	-	-	-	-	-
B5243	43 44	30 37	30 32	-	-	-	37 44	71 80	60 66	-	-	-
B5284	-	44	48 59	-	-	-	35 57	67	32	-	-	-
B5222	44	53	38	-	-	-	-	32	-	-	-	-
B5215	-	-	-	-	-	-	-	31	-	-	-	-

No Procedure, Gain = 70 dB
55-Degree Probe

REF #	TF1	TF2	TF3	TA1	TA2	TA3	BF1	BF2	BF3	BA1	BA2	BA3
B5328	35 38	33	-	-	-	-	31 38	-	-	-	-	-
B5102	38	-	31	-	-	-	-	-	31	-	-	-
B5298	40	42	-	-	-	-	-	-	42 55	-	-	-
B4994	-	-	-	-	-	-	30	32	42	-	-	-
B5227	-	-	43	-	-	34	45	46	48	36	-	-
B4906	-	-	-	-	-	-	-	-	-	-	-	-
B5243	-	-	-	-	-	-	35	46 55	47 48	-	-	-
B5284	31	30	36	-	-	-	45	57	37	-	-	-
B5222	-	32	-	-	-	-	-	-	-	-	-	-
B5215	-	-	-	-	-	-	-	-	-	-	-	-

No Procedure, Gain = 80 dB
65-Degree Probe

REF #	TF1	TF2	TF3	TA1	TA2	TA3	BF1	BF2	BF3	BA1	BA2	BA3
B5328	-	-	-	-	-	-	46 50	46 50	-	52 60	-	-
B5102	-	30 45	45 49	-	40	40	40 41	31 32	-	-	-	-
B5298	-	-	-	-	-	-	-	-	74	30	-	32
B4994	-	32	32	-	-	34		-	-	-	-	-
B5227	-	-	-	-	-	-	-	-	-	-	-	-
B4906	-	-	-	-	-	-	-	-	57	-	-	344
B5243	-	-	-	-	-	-	-	-	-	-	-	-
B5284	-	-	-	-	-	-	35 51	30	-	40	-	-
B5222	-	-	-	-	-	-	-	-	-	-	-	-
B5215	-	-	-	-	-	-	-	-	-	-	-	-

No Procedure, Gain = 70 dB
67-Degree Probe

REF #	CF1	CF2	CF3	CA1	CA2	CA3
B5328	-	-	30	30 40	30	30 43
B5102	30 60	35	40	30	32	-
B5298	-	-	-	-	-	-
B4994	-	-	-	-	-	-
B5227	-	-	-	-	-	-
B4906	-	-	-	-	-	-
B5243	-	-	-	-	-	-
B5284	-	-	-	-	-	-
B5222	-	-	-	-	-	-
B5215	32	52	43	-	-	-

No Procedure, Gain = 70 dB
50-Degree Probe

REF #	TF1	TF2	TF3	TA1	TA2	TA3	BF1	BF2	BF3	BA1	BA2	BA3
B5328	-	-	-	-	-	-	32 40	-	-	-	-	-
B5102	34	-	-	-	-	-	-	30	-	-	-	-
B5298	-	-	-	-	-	-	-	-	46 52	-	-	-
B4994	-	-	-	-	-	-	-	30 39	-	-	-	-
B5227	-	-	-	-	-	-	35	42	30	-	-	-
B4906	-	-	-	-	-	-	-	-	-	-	-	-
B5243	-	-	-	-	-	-	32 38	58 61	49 50	-	-	-
B5284	34	50	44	-	-	-	51	62	30	-	-	-
B5222	30	44	-	-	-	-	-	-	-	-	-	-
B5215	-	-	-	-	-	-	-	-	-	-	-	-

No Procedure, Gain = 80 dB
60-Degree Probe

REF #	TF1	TF2	TF3	TA1	TA2	TA3	BF1	BF2	BF3	BA1	BA2	BA3
B5328	-	30	-	-	-	44	35 36	30 40	-	40	-	-
B5102	-	30	48 52	-	30 39	36	35 38	30	-	-	-	-
B5298	-	-	-	-	-	-	-	-	57	-	-	-
B4994	-	-	-	-	-	-	34	-	-	-	-	-
B5227	-	-	-	-	-	-	-	-	-	38	33	35
B4906	-	-	-	-	-	-	-	-	-	-	-	202
B5243	-	-	-	-	-	-	-	-	-	-	-	-
B5284	-	-	-	-	-	-	30 34	30 40	-	-	-	-
B5222	-	-	-	-	36	-	-	-	-	-	-	-
B5215	-	-	-	-	-	-	-	-	-	-	-	-

APPENDIX IV. PROCEDURE DATA RESULTS

MTL Procedure Data Results (w/o Correction Factor)
45-Degree Probe

REF #	TF1	TF2	TF3	TA1	TA2	TA3	BF1	BF2	BF3	BA1	BA2	BA3
B4906	-	-	-	-	-	-	-	-	-	-	-	-
B4994	-	-	-	-	-	-	-	-	-	-	-	-
B5102	-	-	-	-	-	-	-	-	-	-	-	-
B5215	-	-	-	-	-	-	-	-	-	-	-	-
B5222	-	-	-	-	-	-	-	-	-	-	-	-
B5227	-	-	-	-	-	-	-	-	-	-	-	-
B5243	-	-	-	-	-	-	-	-	-	-	-	-
B5284	-	-	-	-	-	-	-	-	-	-	-	-
B5298	-	-	-	-	-	-	-	-	-	-	-	-
B5328	-	-	-	-	-	-	-	-	-	-	-	-

MTL Procedure Data Results (w/o Correction Factor)
55-Degree Probe

REF #	TF1	TF2	TF3	TA1	TA2	TA3	BF1	BF2	BF3	BA1	BA2	BA3
B4906	-	-	-	-	-	-	-	-	-	-	-	-
B4994	-	-	-	-	-	-	-	-	-	-	-	-
B5102	31	43	31	-	-	-	30	32	30	-	-	-
B5215	-	-	-	-	-	-	-	-	-	-	-	-
B5222	-	-	-	-	-	-	-	-	-	-	-	-
B5227	-	-	54	-	-	36	32	54	54	34	-	-
B5243	-	-	-	-	-	-	-	42	43	-	-	-
B5284	-	-	-	-	-	-	60	52	67	-	-	-
B5298	37	46	-	-	-	-	-	-	42	-	-	-
B5328	35	32	-	-	-	-	37	-	-	-	-	-

MTL Procedure Data Results (w/o Correction Factor)
65-Degree Probe

REF #	TF1	TF2	TF3	TA1	TA2	TA3	BF1	BF2	BF3	BA1	BA2	BA3
B4906	-	-	-	-	-	-	-	-	68	-	-	338
B4994	-	-	-	-	-	-	77	58	-	-	-	-
B5102	78	52	68	35	41	41	-	-	-	-	-	-
B5215	-	-	-	-	-	-	-	-	-	-	-	-
B5222	-	-	-	-	-	-	-	-	-	-	-	-
B5227	70	74	71	82	107	58	75	84	102	90	56	52
B5243	96	-	-	-	-	-	-	70	68	-	-	-
B5284	-	-	-	-	-	-	54	45	-	-	-	-
B5298	-	-	-	-	-	-	-	-	62	47	32	-
B5328	-	-	-	63	-	-	75	77	70	56	65	77

Truton Procedure Data Results
50-Degree Probe

REF #	TF1	TF2	TF3	TA1	TA2	TA3	BF1	BF2	BF3	BA1	BA2	BA3
B4906	-	-	-	-	-	-	-	-	-	-	-	-
B4994	32	42	67	-	32	36	35	112	85	57	45	30
B5102	50	57	100	-	52	42	100	72	80	57	-	-
B5215	45	57	52	-	30	35	65	77	57	57	30	-
B5222	107	117	70	-	-	-	125	105	55	-	-	-
B5227	60	60	65	-	-	60	135	190	97	-	-	-
B5243	77	100	67	-	-	-	57	101	97	-	-	-
B5284	35	72	67	-	-	-	110	110	48	-	-	-
B5298	40	57	35	-	-	-	52	32	125	-	-	-
B5328	75	67	50	-	-	-	102	50	40	-	-	-

Truton Procedure Data Results
60-Degree Probe

REF #	TF1	TF2	TF3	TA1	TA2	TA3	BF1	BF2	BF3	BA1	BA2	BA3
B4906	-	-	-	-	-	-	-	-	31	-	-	54
B4994	-	38	46	-	-	37	41	34	-	43	34	-
B5102	-	-	30	-	50	48	-	-	-	-	-	-
B5215	-	-	-	-	-	-	-	-	-	-	-	39
B5222	-	38	-	-	30	-	-	-	-	-	-	-
B5227	-	-	-	-	-	-	39	34	36	48	39	33
B5243	-	-	-	-	-	-	-	-	-	-	-	-
B5284	-	36	35	-	-	-	31	107	70	-	45	45
B5298	-	-	-	-	-	-	-	-	75	-	-	-
B5328	41	-	-	-	-	39	57	-	-	50	-	-

APPENDIX V. MTL PROCEDURE DATA RESULTS (WITH CORRECTION FACTOR)

45-Degree Probe

REF #	TF1	TF2	TF3	TA1	TA2	TA3	BF1	BF2	BF3	BA1	BA2	BA3
B5328	60 68	61 67	-	-	-	-	82 88	55 68	-	-	-	-
B5102	75	75	68	-	-	-	60	60 62	58	-	-	-
B5298	93 110	71 96	53 65	-	-	-	66 80	64 72	87 91	-	-	-
B4994	-	-	-	-	-	-	56 60	62 66	57 98	-	-	-
B5227	-	-	-	-	-	-	53 64	75	57	-	-	-
B4906	-	-	-	-	-	-	-	-	-	-	-	-
B5243	76 79	52 66	54	-	-	-	68 77	126 134	102 120	-	-	-
B5284	-	78	86 103	-	-	-	65 98	122	57	-	-	-
B5222	75	96	63	-	-	-	-	59	-	-	-	-
B5215	-	54	-	-	-	-	-	-	-	-	-	-

55-Degree Probe

REF #	TF1	TF2	TF3	TA1	TA2	TA3	BF1	BF2	BF3	BA1	BA2	BA3
B5328	104 114	78 90	51 58	-	-	-	78 83	43 48	37 40	-	-	-
B5102	96	71	62	-	40	71	58	75	73	42	-	-
B5298	46 82	73 84	-	-	-	-	41 42	39	102 104	-	-	-
B4994	48	52	46	-	-	50	51	63 70	63 93	54	46	-
B5227	40	41 42	61 121	-	-	78	72 76	117 134	45 69	182	62	37
B4906	-	-	-	-	-	-	-	-	-	-	-	-
B5243	37	36 48	37	-	-	40	40	65 85	78 103	-	-	-
B5284	64	42 69	72 92	-	-	39	124 153	126 146	74 90	106	-	-
B5222	80	81 83	57	-	-	-	-	36	35	-	-	-
B5215	60 67	68	42 48	-	-	-	-	56	58	-	-	-

65-Degree Probe

REF #	TF1	TF2	TF3	TA1	TA2	TA3	BF1	BF2	BF3	BA1	BA2	BA3
B5328	-	-	-	-	-	-	51	55	40	-	-	-
B5102	40	33	36	-	-	-	-	-	-	-	-	-
B5298	-	-	-	-	-	-	-	-	48	-	-	-
B4994	45	45	34	-	-	-	41	36	-	-	-	-
B5227	68	68	64	77	86	55	71	59	64	59	52	73
B4906	-	-	-	-	-	-	-	-	43	-	-	239
B5243	68	51	-	-	-	-	52	63	68	-	-	-
B5284	-	-	-	-	-	-	48	32	-	-	-	-
B5222	-	-	-	-	-	-	-	-	-	-	-	-
B5215	-	-	-	-	-	-	-	-	-	-	-	-

DISTRIBUTION LIST

No. of Copies	To
1	Office of the Under Secretary of Defense for Research and Engineering, The Pentagon, Washington, DC 20301
	Commander, U.S. Army Laboratory Command, 2800 Powder Mill Road, Adelphi, MD 20783-1145
1	ATTN: AMSLC-IM-TL
	Commander, Defense Technical Information Center, Cameron Station, Building 5, 5010 Duke Street, Alexandria, VA 22304-6145
2	ATTN: DTIC-FDAC
1	Metals and Ceramics Information Center, Battelle Columbus Laboratories, 505 King Avenue, Columbus, OH 43201
	Commander, Army Research Office, P.O. Box 12211, Research Triangle Park, NC 27709-2211
1	ATTN: Information Processing Office
	Commander, U.S. Army Materiel Command, 5001 Eisenhower Avenue, Alexandria, VA 22333
1	ATTN: AMCLD
	Commander, U.S. Army Materiel Systems Analysis Activity, Aberdeen Proving Ground, MD 21005
1	ATTN: AMXSY-MP, H. Cohen
	Commander, U.S. Army Electronics Research and Development Command, Fort Monmouth, NJ 07703
1	ATTN: AMDSD-L
1	AMDSD-E
	Commander, U.S. Army Missile Command, Redstone Scientific Information Center, Redstone Arsenal, AL 35898-5241
1	ATTN: AMSMI-RKP, J. Wright, Bldg. 7574
1	AMSMI-RD-CS-R/Doc
1	AMSMI-RLM
	Commander, U.S. Army Armament, Munitions and Chemical Command, Dover, NJ 07801
2	ATTN: Technical Library
1	AMDAR-LCA, Mr. Harry E. Pebly, Jr., PLASTEC, Director
	Commander, U.S. Army Natick Research, Development, and Engineering Center, Natick, MA 01760
1	ATTN: Technical Library
	Commander, U.S. Army Satellite Communications Agency, Fort Monmouth, NJ 07703
1	ATTN: Technical Document Center
	Commander, U.S. Army Tank-Automotive Command, Warren, MI 4397-5000
1	ATTN: AMSTA-ZSK
2	AMSTA-TSL, Technical Library
	Commander, White Sands Missile Range, NM 88002
1	ATTN: STEWS-WS-VT
	President, Airborne, Electronics and Special Warfare Board, Fort Bragg, NC 28307
1	ATTN: Library
	Director, U.S. Army Ballistic Research Laboratory, Aberdeen Proving Ground, MD 21005
1	ATTN: SLCBR-TSB-S (STINFO)
	Commander, Dugway Proving Ground, Dugway, UT 84022
1	ATTN: Technical Library, Technical Information Division
	Commander, Harry Diamond Laboratories, 2800 Powder Mill Road, Adelphi, MD 20783
1	ATTN: Technical Information Office
	Director, Benet Weapons Laboratory, LCWSL, USA AMCCOM, Watervliet, NY 12189
1	ATTN: AMSMC-LCB-TL
1	AMSMC-LCB-R
1	AMSMC-LCB-RM
1	AMSMC-LCB-RP
	Commander, U.S. Army Foreign Science and Technology Center, 220 7th Street, N.E., Charlottesville, VA 22901
1	ATTN: Military Tech

No. of Copies	To
	Commander, U.S. Army Aeromedical Research Unit, P.O. Box 577, Fort Rucker, AL 36360
1	ATTN: Technical Library
	Director, Eustis Directorate, U.S. Army Air Mobility Research and Development Laboratory, Fort Eustis, VA 23604-5577
1	ATTN: SAVDL-E-MOS (AVSCOM)
	U.S. Army Aviation Training Library, Fort Rucker, AL 36360
1	ATTN: Building 5906-5907
	Commander, U.S. Army Agency for Aviation Safety, Fort Rucker, AL 36362
1	ATTN: Technical Library
	Commander, USACDC Air Defense Agency, Fort Bliss, TX 79916
1	ATTN: Technical Library
	Commander, U.S. Army Engineer School, Fort Belvoir, VA 22060
1	ATTN: Library
	Commander, U.S. Army Engineer Waterways Experiment Station, P. O. Box 631, Vicksburg, MS 39180
1	ATTN: Research Center Library
	Commandant, U.S. Army Quartermaster School, Fort Lee, VA 23801
1	ATTN: Quartermaster School Library
	Naval Research Laboratory, Washington, DC 20375
1	ATTN: Code 5830
2	Dr. G. R. Yoder - Code 6384
	Chief of Naval Research, Arlington, VA 22217
1	ATTN: Code 471
1	Edward J. Morrissey, AFWAL/MLTE, Wright-Patterson Air Force, Base, OH 45433
	Commander, U.S. Air Force Wright Aeronautical Laboratories, Wright-Patterson Air Force Base, OH 45433
1	ATTN: AFWAL/MLC
1	AFWAL/MLLP, M. Forney, Jr.
1	AFWAL/MLBC, Mr. Stanley Schulman
	National Aeronautics and Space Administration, Marshall Space Flight Center, Huntsville, AL 35812
1	ATTN: R. J. Schwinghammer, EH01, Dir, M&P Lab
1	Mr. W. A. Wilson, EH41, Bldg. 4612
	U.S. Department of Commerce, National Institute of Standards and Technology, Gaithersburg, MD 20899
1	ATTN: Stephen M. Hsu, Chief, Ceramics Division, Institute for Materials Science and Engineering
1	Committee on Marine Structures, Marine Board, National Research Council, 2101 Constitution Ave., N.W., Washington, DC 20418
1	Librarian, Materials Sciences Corporation, Guynedd Plaza 11, Bethlehem Pike, Spring House, PA 19477
1	The Charles Stark Draper Laboratory, 68 Albany Street, Cambridge, MA 02139
	Wyman-Gordon Company, Worcester, MA 01601
1	ATTN: Technical Library
	Lockheed-Georgia Company, 86 South Cobb Drive, Marietta, GA 30063
1	ATTN: Materials and Processes Engineering Dept. 71-11, Zone 54
	General Dynamics, Convair Aerospace Division, P.O. Box 748, Fort Worth, TX 76101
1	ATTN: Mfg. Engineering Technical Library
1	Mechanical Properties Data Center, Belfour Stulen Inc., 13917 W. Bay Shore Drive, Traverse City, MI 49684
1	Mr. R. J. Zentner, EAI Corporation, 626 Towne Center Drive, Suite 205, Joppatowne, MD 21085-4440
	Director, U.S. Army Materials Technology Laboratory, Watertown, MA 02172-0001
2	ATTN: SLCMT-TML
3	Authors

U.S. Army Materials Technology Laboratory
Watertown, Massachusetts 02172-0001
COMPARATIVE ANALYSIS OF ULTRASONIC INSPECTION PROCEDURES FOR KAMAN K747 ROOT END FITTINGS - Walter N. Roy, Philip G. Bennett, and Bradley M. Taber III

AD__________
UNCLASSIFIED
UNLIMITED DISTRIBUTION

Technical Report MTL TR 89-27, April 1989, 63 pp-illus-tables, AMCMS Code P730000

Key Words

Aluminum
Ultrasonics
Attack helicopters

The attached report provides a comparative analysis of two ultrasonic inspection procedures for Kaman Aerospace Corporation's K747 root end fittings. The procedure currently being used was originally developed by Truton under contract through Kaman Aerospace, the fabricator of the root end fitting. The other procedure is a revision of the existing Truton procedure which was prepared by the U. S. Army Materials Technology Laboratory (MTL). Both procedures were compared against a sample of ten previously rejected root end fittings. Table 1 provides, at a glance, the major differences between the two procedures.

U.S. Army Materials Technology Laboratory
Watertown, Massachusetts 02172-0001
COMPARATIVE ANALYSIS OF ULTRASONIC INSPECTION PROCEDURES FOR KAMAN K747 ROOT END FITTINGS - Walter N. Roy, Philip G. Bennett, and Bradley M. Taber III

AD__________
UNCLASSIFIED
UNLIMITED DISTRIBUTION

Technical Report MTL TR 89-27, April 1989, 63 pp-illus-tables, AMCMS Code P730000

Key Words

Aluminum
Ultrasonics
Attack helicopters

The attached report provides a comparative analysis of two ultrasonic inspection procedures for Kaman Aerospace Corporation's K747 root end fittings. The procedure currently being used was originally developed by Truton under contract through Kaman Aerospace, the fabricator of the root end fitting. The other procedure is a revision of the existing Truton procedure which was prepared by the U. S. Army Materials Technology Laboratory (MTL). Both procedures were compared against a sample of ten previously rejected root end fittings. Table 1 provides, at a glance, the major differences between the two procedures.

U.S. Army Materials Technology Laboratory
Watertown, Massachusetts 02172-0001
COMPARATIVE ANALYSIS OF ULTRASONIC INSPECTION PROCEDURES FOR KAMAN K747 ROOT END FITTINGS - Walter N. Roy, Philip G. Bennett, and Bradley M. Taber III

AD__________
UNCLASSIFIED
UNLIMITED DISTRIBUTION

Technical Report MTL TR 89-27, April 1989, 63 pp-illus-tables, AMCMS Code P730000

Key Words

Aluminum
Ultrasonics
Attack helicopters

The attached report provides a comparative analysis of two ultrasonic inspection procedures for Kaman Aerospace Corporation's K747 root end fittings. The procedure currently being used was originally developed by Truton under contract through Kaman Aerospace, the fabricator of the root end fitting. The other procedure is a revision of the existing Truton procedure which was prepared by the U. S. Army Materials Technology Laboratory (MTL). Both procedures were compared against a sample of ten previously rejected root end fittings. Table 1 provides, at a glance, the major differences between the two procedures.

U.S. Army Materials Technology Laboratory
Watertown, Massachusetts 02172-0001
COMPARATIVE ANALYSIS OF ULTRASONIC INSPECTION PROCEDURES FOR KAMAN K747 ROOT END FITTINGS - Walter N. Roy, Philip G. Bennett, and Bradley M. Taber III

AD__________
UNCLASSIFIED
UNLIMITED DISTRIBUTION

Technical Report MTL TR 89-27, April 1989, 63 pp-illus-tables, AMCMS Code P730000

Key Words

Aluminum
Ultrasonics
Attack helicopters

The attached report provides a comparative analysis of two ultrasonic inspection procedures for Kaman Aerospace Corporation's K747 root end fittings. The procedure currently being used was originally developed by Truton under contract through Kaman Aerospace, the fabricator of the root end fitting. The other procedure is a revision of the existing Truton procedure which was prepared by the U. S. Army Materials Technology Laboratory (MTL). Both procedures were compared against a sample of ten previously rejected root end fittings. Table 1 provides, at a glance, the major differences between the two procedures.